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MIDDLE CREEK DAM REHABILITATION

DESIGN REPORT

OCTOBER 1990

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MIDDLE (HYALITE) CREEK DAM REHABILITATION

DESIGN REPORT

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LIST OF ABBREVIATIONS

@ - At
AASHTO - American Association of State Highway and Transportation Officials
ACI - American Concrete Institute
CBR - California Bearing Ratio
cfs - Cubic feet per second
COE - U.S. Army Corps of Engineers
DNRC - Department of Natural Resources and Conservation
EAL - Equivalent axle load
EQ - Earthquake
FS - Factor of Safety
ft. - Feet
g - Acceleration of gravity
H - Horizontal
HKM - HKM Associates, Engineering Consultant, Billings, MT
HEC - Hydrologic Engineering Center
K - One Thousand
MCWUA - Middle Creek Water Users Association
MDOH - Montana Department of Highways
NGVD - National Geodetic Vertical Datum
NWS - National Weather Service
PCF - Pounds per cubic foot
PMF - Probable maximum flood
PMP - Probable maximum precipitation
PSF - Pounds per square foot
PSI - Pounds per square inch
SCS - U.S. Soil Conservation Service
SDF - Spillway Design Flood
USBR - U.S. Bureau of Reclamation
USFS - U.S. Forest Service
V - Vertical
° - Degrees
' - Minutes

A. INTRODUCTION

Plans for the Rehabilitation of the Middle Creek Dam and Reservoir have been progressing since 1980. A number of engineering investigations have been accomplished to increase storage and bring the project into conformance with modern dam safety criteria.

Final design, preparation of drawings and specifications, and construction management services are currently being provided to the Department of Natural Resources and Conservation (DNRC) by HKM Associates (HKM). These are being provided under Contract No. WE-HKM-239.

PURPOSE OF DESIGN REPORT

The purpose of this Design Report is to present the criteria used and the engineering decisions made in preparing the construction drawings (APPENDIX A-1, full and half size drawings available under separate cover) and specifications (APPENDIX A-2, under separate cover) for the project.

The design process included a series of coordination meetings with DNRC and the federal reviewing agencies. A series of design working papers were prepared by HKM to facilitate coordination and review. The working papers are included in the text and appendices of this design report.

This report is intended to present all significant data generated, criteria used, and engineering decisions made. Since the Loan Application Report was published (HKM, 1987) new plan formulation alternatives were developed and are presented herein. This report, however, is not intended to include a complete summary of all available information pertinent to the final design. Reference will be made to earlier documents to supplement data presented herein.

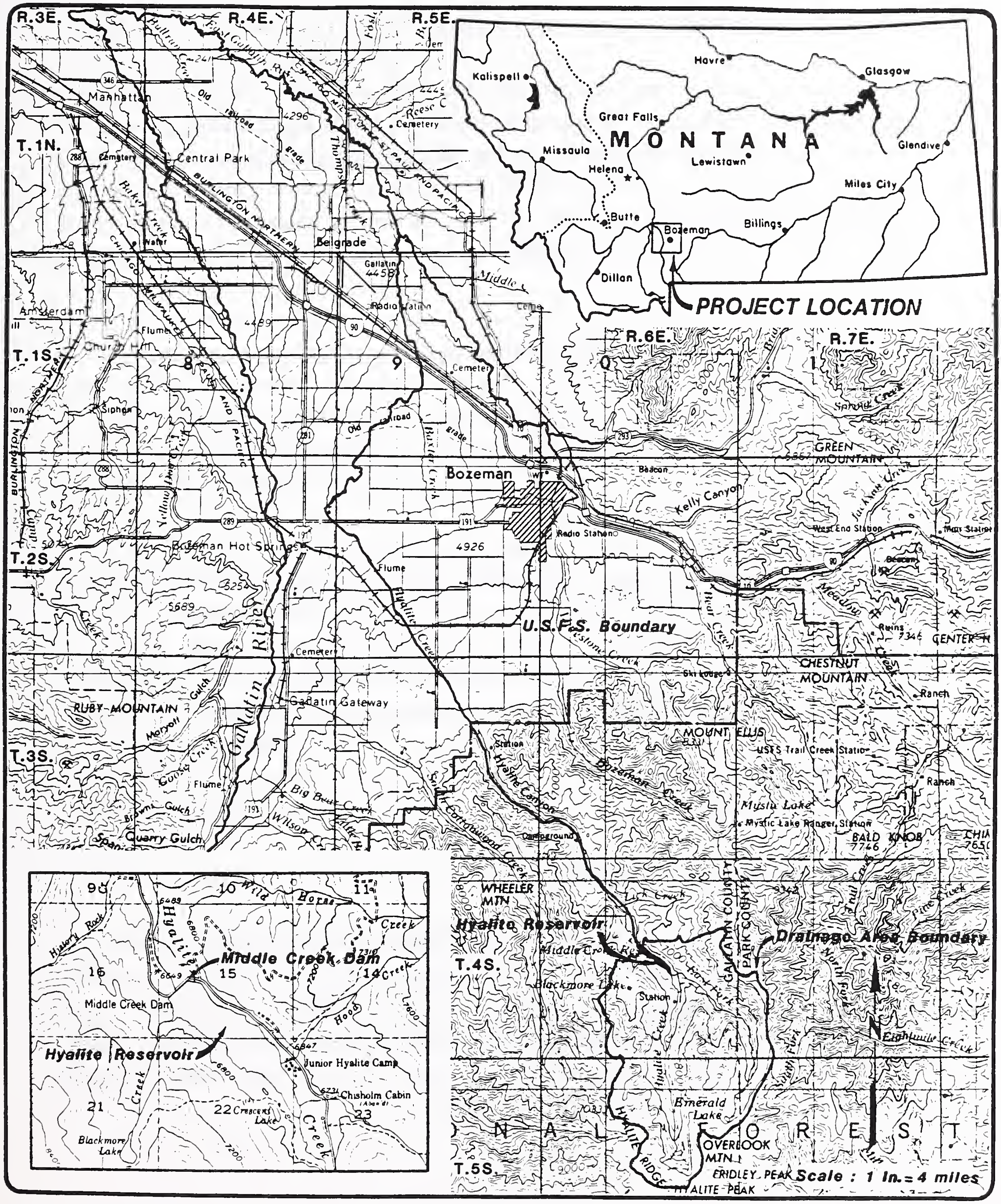
PROJECT LOCATION

Middle Creek Dam and Reservoir (also known as Hyalite Reservoir) are located approximately 15 miles south of Bozeman, Montana in Gallatin County, within the Gallatin National Forest. (See Figure 1). The dam and reservoir occupy portions of Sections 15, 22 and 23, T4S, R6E. The drainage basin area above the dam is 27 square miles including primarily the East and West Forks of Hyalite Creek. The facilities are state owned and are operated and maintained by the Middle Creek Water Users Association (MCWUA). The DNRC constructed the dam under the provisions of a Special Use Permit from the U.S. Forest Service (USFS). Operation of the dam began in the fall of 1951.

EXISTING PROJECT

The existing dam is a zoned earthfill structure approximately 117 feet in height (measured from the top of dam elevation 6722 feet NGVD to streambed elevation 6605 feet NGVD at downstream toe). At centerline it has a structural height of 111 feet based on findings of the 1983 geotechnical investigation. The crest length is approximately 1300 feet long. A 60-inch diameter low level outlet conduit is located near the center of the main embankment. A 40-foot wide concrete spillway with an ogee crest is located on the right abutment.

The existing principal spillway crest is at 6710.8 feet NGVD with a reservoir surface area of 204 acres and a total storage capacity of 7,976 AF. With 2 feet of flashboards these values are 6712.8 feet NGVD, 213 acres, and 8,393 AF. These are total storage amounts including 126 AF of dead storage.


R.3E.
R.4E.
R.5E.
R.6E.
R.7E.
T.1N.
T.1S.
T.2S.
T.3S.
T.4S.
T.5S.
Manhattan
Central Park
Belgrade
Amsterdam
Church Hill
Bozeman
Bozeman Hot Springs
Gallatin Gateway
Gallatin River
BURLINGTON NORTHERN
CHICAGO MILWAUKEE ST. PAUL AND PACIFIC
Kelly Canyon
GREEN MOUNTAIN
CHESTNUT MOUNTAIN
MOUNT ELLIS
Bozeman Creek
Mystic Lake
Mystic Lake Ranger Station
BALD KNOB 7746
RUBY MOUNTAIN
Quarry Gulch
U.S.F.S. Boundary
Hyalite Canyon
Hyalite Creek
South Cottonwood Creek
WHEELER MTN
Hyalite Reservoir
Middle Creek Res.
Blackmore Lake
Drainage Area Boundary
GALLATIN COUNTY
PARK COUNTY
Emerald Lake
OVERLOOK MTN
FRIDLEY PEAK
HYALITE PEAK
HYALITE RIDGE
N A L F O R E S T
Scale : 1 In. = 4 miles
Kalispell
Havre
Glasgow
Great Falls
MONTANA
Missoula
Helena
Lewistown
Glendive
Miles City
Butte
Billings
Bozeman
Dillon
PROJECT LOCATION
Middle Creek Dam
Hyalite Reservoir
Wild Horse Creek
History Rock
Hood Creek
Junior Hyalite Camp
Chisholm Cabin
Crescent Lake
Blackmore Lake

MIDDLE CREEK DAM REHABILITATION

GENERAL LOCATION MAP

FIGURE I

HKM ASSOCIATES
ENGINEERS-PLANNERS

PROBLEM STATEMENT

Based on a U.S. Army Corps of Engineers (COE) Phase I study, (COE, 1980) Middle Creek Dam is rated a large dam with a high downstream hazard potential. Presently the dam can safely pass only 29 percent of the probable maximum flood (PMF) while the recommended spillway design flood (SDF) is the full PMF. The dam has a seriously inadequate spillway and is considered unsafe.

A breach of the dam embankment could occur as a result of overtopping during a large flood event. Damages from the resulting flood could exceed $30 million plus the cost of repairing the dam. The purpose of this rehabilitation is to bring the dam up to present dam safety standards and provide additional storage capacity.

The Phase I report made recommendations for project improvement to correct existing conditions which did not conform to COE recommended guidelines. Key recommendations called for (1) restoration of the principal spillway structure, (2) hydrologic and hydraulic investigations to determine required spillway capacity and downstream hazards, (3) determination of embankment stability, and (4) locating the source of seepage in the left abutment.

SUMMARY OF EARLIER INVESTIGATIONS

DNRC responded to the COE recommendations by initiating a series of investigations that culminated in a rehabilitation plan. HKM, under contract with DNRC, provided the investigations and prepared the feasibility study (HKM, 1985) and loan application report (HKM, April 1987) that defined the rehabilitation plan for this project.

HKM has prepared the following documents directly related to the work proposed herein:

- HKM Associates. November 1983. Hydrologic Potential for Hyalite Creek Watershed. Billings, Montana.
- HKM Associates. April 1984a. Flood Hydrology, Middle Creek Dam. Billings, Montana.
- HKM Associates. April 1984b. Geotechnical Investigation, Middle Creek Dam. Billings, Montana.
- HKM Associates. February 1985. Middle (Hyalite) Creek Dam Rehabilitation Feasibility Study. Billings, Montana.
- HKM Associates. December 1986. Middle Creek Dam Rehabilitation Environmental Assessment. Billings, Montana.
- HKM Associates. April 1, 1987. Middle Creek Dam Rehabilitation Loan Application Report. Billings, Montana.

REHABILITATION PLAN

The principal project features of the rehabilitation plan are:

- Enlargement of the dam embankment by 8 feet using an earth reinforced structure in the center of the dam and conventional earthfill on the ends. The top of the impervious section will be 6729.9 feet NGVD.

- Increase the normal water surface by 8.2 feet (from the top of existing flashboards), enlarging the total reservoir capacity from 8,393 AF to 10,310 AF providing an additional 1,917 AF of storage. All storage not presently contracted (2,334 AF) is allocated to municipal use.

- An earthen auxiliary spillway excavated in the left abutment which has a base width of 530 feet wide at the crest transitioning to 70 feet wide at the end. A concrete crest control structure will be constructed. An excavated channel and dike will be constructed below the spillway leading flood flows back to Hyalite Creek.

- An improved principal spillway will include an inlet weir, a baffled apron drop constructed in the existing spillway, and a channel and dike leading to a new baffled apron drop structure to Hyalite Creek.

- Riprap of the outlet conduit discharge area.

- Relocation and construction of replacement campground facilities and boat ramps.

- Reconstruct the road across the dam with a new bridge across the principal spillway.

- Provide a pedestrian bridge across the principal spillway.

- Construction of grayling mitigation structures.

PROJECT DATA

General

a.	Type	Earthfill with Mechanically Stabilized Earth Crest
b.	Height (feet above D/S channel toe)	125
c.	Crest length	1900 feet
d.	Crest width	37.5 feet
e.	Upstream slope	2H:1V, 3H:1V and 4H:1V, variable, refer to plans
f.	Downstream slope	2H:1V and 4H:1V, variable, refer to plans
g.	Maximum surcharge (Elev. 6729.9)	12,790 acre-feet
h.	Total storage (Elev. 6721.0)	10,310 acre-feet
i.	Active storage (Elev. 6721.0)	10,184 acre-feet
j.	Inactive storage (Elev. 6637.0)	126 acre-feet
k.	Dam crest	6730.0
l.	County-State	Gallatin County, Montana
m.	Location	Section 15, Township 4S, Range 6E
n.	Watershed location	Middle Creek, tributary to East Gallatin River, tributary to Gallatin River, tributary to Missouri River
o.	Year completed	1991-92
p.	Drainage area	27 square miles
q.	Probable Maximum Flood (PMF)	30,500 cfs

__Upper Principal Spillway__ (elevations in feet NGVD)

a.	Type	Baffled apron drop with labyrinth crest
b.	Length along flowline	182 feet
c.	Crest elevation (normal pool)	6721.0
d.	Maximum observed flow	Unknown, new
e.	Capacity at auxiliary Spillway-crest (6723.0)	1240 cfs
f.	Capacity at maximum surcharge (6729.9)	3250 cfs

__Lower Principal Spillway__ (elevations in feet NGVD)

a.	Type	Baffled apron drop
b.	Length along flowline	212 feet
c.	Crest elevation	6683.3
d.	Maximum observed flow	Unknown, new
e.	Capacity at maximum reservoir surcharge (6729.9) if dike does not fail	2000 cfs

__Auxiliary Spillway__ (elevations in feet NGVD)

a.	Type	Earthen spillway
b.	Length	1150 feet
c.	Crest elevation	6723.0
d.	Maximum observed flow	Unknown, new
e.	Capacity at maximum surcharge (6729.9)	27,250 cfs
f.	crest length	530 ft curved

Outlet Works (elevations in feet NGVD)

a.	Size	5-foot diameter, steel lined, cast in place concrete
b.	Control	One 54-inch diameter butterfly valve (operating) and one 54-inch diameter gate valve (emergency)
c.	Approximate capacity at normal pool (Elev. 6721.0)	800 cfs
d.	Design inlet invert elev.	6637.0
e.	Design outlet invert elev.	6630.5
f.	Drain system	Jet pump in control tower
g.	Trashrack	Yes
h.	Length	600 feet

An elevation-area-capacity table and rating tables for the principal spillway, auxiliary spillway, and outlet works are provided serparately in the "Manual for Operation and Maintenance".

B. HYDROLOGY

A feasibility level design for the rehabilitation of Middle Creek Dam was reported in the loan application report (HKM, April 1987). In preparing the final design, the PMF and associated spillways design have been re-evaluated to incorporate information that has become available since the feasibility study which was completed in 1984. This section presents the design criteria that was used in final design for the design flood and freeboard requirements.

DESIGN FLOOD

The PMF was re-evaluated using several different approaches (see Appendix B-2). During a meeting of the USBR, DNRC and HKM on March 24, 1988 at the Engineering and Research Center in Denver, Colorado, it was decided that a PMF having a peak flow of 30,500 cfs is most appropriate for use at Middle Creek Dam. The USBR and USFS again approved in concept the PMF at the agency review meeting held on March 31, 1988 at the HKM offices in Billings, Montana. The COE's HEC-1 computer output showing the revised PMF and reservoir routing is located in Appendix B-1. Additional information pertaining to the revised PMF is located in Appendix B-2.

FREEBOARD

The amount of freeboard during the PMF was also discussed with the USBR at the March 24, 1988 meeting. The USBR stated that it would be acceptable to allow the maximum water surface to rise to the top of the impervious section of the dam during the 30,500 cfs PMF. During a PMP general storm, SCS and NWS meteorologists predict that there would not be any significant wind associated with the flood peak. Any wind associated with the storm would be from the east which would blow waves away from the dam. It is also believed that any winds associated with a thunderstorm event would precede the rain and runoff. This confirms that allowing water to rise to the top of the impervious surface is an appropriate criteria to utilize at Middle Creek Dam. The freeboard methodology was again approved by the USBR and USFS at the March 31, 1988 agency review meeting. Additional freeboard information is found in Appendix B-3.

After review of this criteria, DNRC and HKM have selected the following elevations for final design:

Principal Spillway Crest = 6721.0
Auxiliary Spillway Crest = 6723.0
Reservoir Water Surface @ 30,500 cfs = 6729.9
Top of Impervious Section = 6729.9

C. GEOTECHNICAL

A geotechnical investigation was performed as part of the final design for the Middle Creek Dam Rehabilitation project. The geotechnical investigation included a field drilling program, a ground water monitoring program, soil laboratory testing and material source identification for borrow selection. Each of these portions of the investigation will be described in the design report. Geotechnical considerations not included here are found in other sections of the report.

The geotechnical investigation was performed in two parts. The first part was an investigation for the Middle Creek Dam Rehabilitation Feasibility Study. This study was done in 1983 and 1984. That study consisted of a field drilling program, the geological investigation, laboratory testing, engineering analysis and seepage monitoring.

The 1983-84 geotechnical investigation included fifteen exploration drill holes and fourteen test pits to determine soil conditions and obtain samples for laboratory testing. Instrumentation, to monitor embankment movement and changes in ground water levels, was installed. A geologic investigation was made to assist in evaluating the soils and the impact of a seismic event on Middle Creek Dam. The engineering analyses included seepage and stability studies. Both static and dynamic stability analyses were performed.

Rehabilitation alternatives were conceptualized at that time, however, design details had not yet been developed. Additional geotechnical work was required to develop the final design.

The results were reported (HKM, 1984b). The detailed information will not be repeated herein except for general conclusions and findings relating to design criteria as appropriate.

The second investigation began in 1987 and is concluded with this report. It included a field drilling program, laboratory testing, borrow source investigation, and engineering analyses. The results are presented in detail herein.

FIELD INVESTIGATION

The geotechnical investigation was performed to accomplish the following:

- Determine the sub-surface conditions at the proposed upper and lower principal spillway structures.
- Expand knowledge of the sub-surface conditions in the auxiliary spillway area.
- To monitor the phreatic surface throughout the existing embankment and in the left abutment.
- To perform borrow and materials investigation specific for final design.

A field exploration program was performed during November and December of 1987. The investigation consisted of exploration borings using a truck mounted drill rig and a borrow investigation using a backhoe.

The field exploration program included 8 drill holes and 14 exploration test pits. The locations of these holes are shown on Sheet Nos. 41 and 44 in Appendix A-1 of this report. The drilling was performed by Rollins, Brown & Gunnell, Inc., Provo, Utah, under the direction of a HKM professional engineer and a HKM professional geologist.

The borings were extended to depths from 41.5 feet to 121 feet. Ground water levels were measured and soil samples were taken for field classification. Logs of the exploration holes were made and are detailed on the logs of exploration holes (Appendix A-1, Sheet 57 and 60).

The informational goal of each drill hole (DH) and test pit (TP) including those from the previous investigation (HKM, 1984b) is summarized in Table 1.

TABLE 1

INFORMATION GOAL OF EXPLORATION HOLES

EXPLORATION HOLE NO.	PURPOSE
DH-1	To investigate the foundation of the existing spillway and determine excavation needs
DH-2	To investigate the foundation of spillway and the character of the abutment
DH-3	To investigate the right abutment
DH-4	To determine the depth to bedrock and obtain undisturbed samples of the foundation; critical for the dynamic analysis
DH-5	To investigate the pervious section of the dam and the foundation; critical for dynamic analysis
DH-6	To investigate the semi-pervious section of the embankment and identify the phreatic surface; critical for the dynamic analysis

TABLE 1

INFORMATION GOAL OF EXPLORATION HOLES (Continued)

EXPLORATION HOLE NO.	PURPOSE
DH-7	To investigate the impervious section of the embankment; critical for the static and dynamic stability analyses
DH-8	To investigate the left abutment
DH-9	To investigate the seepage in the left abutment
DH-10	To investigate the left abutment
DH-11	To investigate the potential auxiliary spillway area
DH-12	To investigate soils in area of the potential auxiliary spillway
DH-13	To investigate the old landslide in the right abutment
DH-13A	To redrill DH-13 as it was lost due to difficult drilling
DH-14	To investigate the right abutment at the contact with the downstream slope
DH-201	To investigate foundation conditions at the toe of the proposed lower baffled apron drop
DH-202	To investigate the foundation at the upper end of the proposed lower baffled apron drop

TABLE 1
INFORMATION GOAL OF EXPLORATION HOLES (Continued)

EXPLORATION HOLE NO.	PURPOSE
DH-203	To investigate the position of the phreatic surface in the left abutment and to help evaluate the pervious section of the existing embankment
DH-204	To better define the phreatic surface through the embankment and left abutment
DH-205	To investigate the location of the phreatic surface through the embankment and left abutment
DH-206	To investigate the location of the phreatic surface between drill holes DH-5 and DH-6 on the maximum section of the embankment
DH-207	To investigate the subsoil conditions at the toe of the upper baffled apron drop in the principal spillway
DH-208	To investigate the subsoil conditions in a seepage area at the toe of the existing small landslide
TP-101	To investigate the ease of excavation of the principal spillway
TP-102	To obtain a bulk sample of the pervious section of the embankment and to observe seepage
TP-103	To obtain a bulk sample of the impervious section of the embankment and to investigate the old landslide area

TABLE 1

INFORMATION GOAL OF EXPLORATION HOLES (Continued)

EXPLORATION HOLE NO.	PURPOSE
TP-104	To investigate the upstream impervious blanket on the left abutment
TP-105	To investigate the ease of excavation of the potential auxiliary spillway area
TP-106, 107 & 111	To obtain a bulk sample of the borrow from the potential auxiliary spillway excavation and observe seepage
TP-108-110	To obtain samples of the borrow areas on the east side of the reservoir
TP-112-113	To investigate the potential borrow area on the mountain side above the right abutment
TP-114	To investigate the area of the trench drain on the left abutment downstream from the embankment
TP-301	To investigate foundation conditions at the toe of the lower baffled apron drop
TP-302	To investigate foundation conditions at the lower baffled apron drop
TP-303	To investigate foundation conditions at the site of the proposed labyrinth weir

TABLE 1

INFORMATION GOAL OF EXPLORATION HOLES (Continued)

EXPLORATION HOLE NO.	PURPOSE
TP-304	To investigate foundation conditions at a potential site for a bridge which would provide access to the Edsall cabin
TP-305 & 306	To investigate foundation conditions in the proposed campground areas
TP-309	To determine the condition of the existing drain system in the left abutment
TP-310	To evaluate the foundation conditions at the training dike which is part of the auxiliary spillway system
TP-307, 308 TP-311 thru TP-314	To investigate the characteristics of materials to be excavated from the auxiliary spillway

Source: HKM Associates

Field permeability tests were taken in each exploration drill hole and laboratory samples were obtained for testing. Monitoring tubes were installed in each of the exploration drill holes. A description of the completion of each of these holes is provided on Sheet Nos. 41-43 in Appendix A-1.

Slope stability monitoring tubes were also installed in Drill Holes No. 5 and 208. The purpose of these tubes is to monitor potential horizontal movements in the downstream embankment slope and the right abutment, respectively.

Drill pads were constructed to provide access to many of the exploration holes. These access roads and drilling pads were constructed using a dozer and were reclaimed upon completion of the work. Complete reclamation included recontouring of the ground surface, construction of runoff control appurtenances using stop logs, reseeding the area and removal of downed timber. This reclamation work has been reviewed and approved by the USFS.

Protective caps were constructed for each of the exploration drill holes. The method of the construction was the same as for the previous work (HKM, 1984) with the exception that a loose fitting slip-on cap was placed over the casing instead of a screw-on cap to provide future access to the monitoring tubes.

LABORATORY ANALYSES

Representative field samples were selected for laboratory testing after careful visual examination of the soil and consideration of the design criteria. Most of the physical and engineering soils property tests were performed in the HKM laboratory in Billings, Montana. Some engineering property tests and chemical tests were performed by Lyndes Laboratory in Billings, Montana.

Test	Purpose of Test
Natural Moisture Content (ASTM D-2216)	To determine the natural (in situ) water content and to correlate the moisture contents with the phreatic surface.
Atterberg Limits (ASTM D-423 & D-424)	To provide an indication of the shear strength and compressibility of the soil.

Test	Purpose of Test
Particle-Size Distribution (ASTM D-422)	To determine the grain sizes of the soils for classification and identification of physical characteristics.
Natural Unit Density (ASTM D-2937)	To determine the (in situ) dry unit weight of the soil.
Moisture - Density Curve (ASTM D-698)	To determine the relationship of water to the density of soil during a compaction or remolding process.
Laboratory Bearing Ratio (ASTM D-1883)	To measure the shearing resistance of soil under controlled moisture and density conditions. Used to evaluate the relative quality of subgrade soils for pavement support.
Laboratory Permeability	To determine the permeability of soils remolded to simulate embankment construction.
Corrosivity SO_4, pH, Resistivity	To determine the corrosion potential of soils on buried metal and concrete
Direct shear (ASTM D-3080)	To determine the shear strength of the soils
L.A. Abrasion	To determine the quality of rock relative to hardness.

The laboratory tests were performed in strict accordance with applicable ASTM procedures. A Summary of the Laboratory Test Results is presented on the Geotechnical Information sheets of Appendix A-1. Additional test data for individual tests is presented on Figures 1-13 of Appendix C-1.

Laboratory test results from the earlier geotechnical report, Middle Creek Dam Geotechnical Investigation, April 1984, are presented on Plate Nos. 1-27 in Appendix C-1. These results are included to provide a complete compilation of soils grain-size distribution tests.

FINDINGS

This section presents general engineering considerations based on the results from the geotechnical investigation. Some items are only briefly discussed in this section but are detailed in other pertinent sections of this report.

Foundation Conditions at Principal Spillway

Three exploration holes were made along the alignment of the principal spillway, DH-201, DH-202 and DH-207. One of the primary purposes of these holes was to determine the depth to bedrock. The findings indicate that bedrock is well below these structures. Therefore, soil anchors are designed for structural stability.

The natural foundation soils are tills and are primarily gravel with some clay and sand. Because of the high quantity of clay in the till soil, the clay typically governs the shear strength. Therefore, anchor capacities are limited.

Results of the exploration borings also indicate that ground water at the lower baffled apron drop structure is near the stream elevation. It is anticipated that during periods of high precipitation and when the pool is near full the ground water may raise significantly.

A detailed explanation of the design criteria and design of the soil anchors for the baffled apron drop structures is discussed in Appendix F-3.

Monitoring

The phreatic surface through the embankment and ground water in the abutments at the site has been monitored extensively since 1984. The monitoring has been performed in a joint effort between personnel from HKM and the DNRC.

Exploration holes DH-204 through DH-206 were located for the purpose of identifying the phreatic surface through the existing embankment. Although the location of the phreatic surface was previously identified and reported in the April 1984 geotechnical report, additional exploration was needed to confirm its location along another cross section through the embankment. Results of the monitoring have confirmed that the phreatic surface previously identified appears to be correct. With at least two locations indicating the location of the phreatic surface, confidence is gained in the seepage model. Seepage analysis through the embankment is described under the Embankment section.

Four additional monitoring wells (DH-301 through DH-304) were installed in August 1990. These wells will serve to monitor the performance of the barrier drain after rehabilitation. These four wells and 14 others that will be disturbed during rehabilitation construction were equipped with vibrating wire piezometers to allow for measurement after rehabilitation.

Seepage has been identified near the surface at the contact between the embankment and the right abutment on the downstream face. This seepage was identified in the earlier report and was investigated again during this exploration program. Results of the field monitoring program suggests that there is more seepage in this area than was previously identified. A trench drain has been designed to control the seepage.

The existing drain on the left abutment (1956 Rehabilitation) discharges approximately 200 ft. horizontally and 50 ft. vertically from the outlet channel. Discharge from this drain flows along the abutment contact to the outlet channel at the downstream end of the outlet conduit. New pipe drain will be installed to extend the existing drain to the outlet channel. This will keep the surface flow off the abutment and allow for measurement of flow.

In April 1984 a slope indicator tube was placed in DH-5 on the main embankment. Slope movements have been monitored in this hole and results indicate that surface sloughing is occurring on the face of the embankment. It is felt that this sloughing is minor and typical of earth embankments. Movements since installation have been less than ½ inch near the ground surface. There is some indication that the movement may be related to disturbance by vehicles crossing the berm of the embankment during the exploration program. In any case, the results suggest that there is not a particular concern with stability on the downstream face of the embankment.

A slope monitoring tube was also installed in DH-208 during 1987. The purpose of this tube is to monitor slope movements on the right abutment. During this investigation a small landslide has been identified on the right abutment slightly downstream of the embankment. This slide appears to be shallow, approximately three to five feet deep, and 20 to 40 vertical feet in height. The slide is approximately 30 feet in width. The exact dimensions of the slide are not obvious. Surface sloughing appears to be occurring as a result of high ground water and low strength soils. This slide does not appear to impact embankment stability.

Dewatering

The following areas may require dewatering during construction:

- The downstream toe of the upper baffled apron drop.
- The right abutment and wall area of the upper baffled apron drop.
- The upstream entrance area for the lower baffled apron drop.
- The downstream toe of the lower baffled apron drop.
- The dike foundation area between the upper and lower baffled apron drops.
- Excavation in the auxiliary spillway area.

There is a spring located in the area of DH-207 adjacent to the upper baffled apron drop. Ground water was encountered near Elevation 6698 feet NGVD. This spring creates hydrostatic pressures behind the east wall of the existing principal spillway. The proposed construction for the new spillway will require that this water be controlled during construction. Additionally, subsurface drainage behind the east wall of this upper spillway structure will be required. A description of the drain design is presented in Section F, Principal Spillway.

The static ground water elevation at the toe of the upper baffled apron drop is near elevation 6697.6 feet NGVD (November 18, 1987). It is anticipated that the static water elevation may increase after the rehabilitation construction and the pool is filled.

Presently, there is a swamp like condition in the area of the training dikes between the upper and lower baffled apron drop structures. High ground water in this area is the result of springs from the east and from minor seepage through the embankment and abutment near the existing spillway. Saturated conditions in this area during the early spring and summer months may create construction problems. Dewatering should be anticipated in this area.

At the upper end of the lower baffled apron drop there is an existing drainage channel from the swampy area previously described. During the summer months, surface waters from the swamp flow into the channel creating saturated soils. Dewatering in this area may be reduced if the swampy area previously described is also dewatered. Surface runoff from this area may also create problems during construction and should be controlled.

The static water elevation at the downstream toe of the lower baffled apron drop is near or slightly above the stream elevation. Springs from the east create saturated conditions above the streambed in some areas. It is possible that a spring will develop during foundation construction for the lower baffled drop.

Dewatering is anticipated at the toe of the lower baffled apron drop. The primary source for this water will be from the low level outlet conduit under the existing embankment. Because of the high porosity and permeability of the soils in this area large dewatering volumes should be anticipated. Underdrains are designed to handle seepage after construction. This drainage control is described in the Principal Spillway Section.

Presently there is a spring in the area of the proposed auxiliary spillway. It is expected that this spring will continue to flow during construction. Deep soft sediments are located where spring water ponds in the auxiliary spillway area. Equipment may find it difficult to work in these saturated soils. De-watering may be accomplished by sub-surface trench drains. Surface drainage may also be used provided it does not have to be crossed by heavy equipment.

D. EMBANKMENT

To control the PMF, the top of the impervious embankment must be raised to elevation 6729.9 feet NGVD. At the earth reinforced structure the minimum elevation of the impervious upstream face will be 6730.0 feet NGVD.

The rehabilitation of the existing Middle Creek Dam embankment consists of two general items:

- Construction of an earth reinforced structure across the main portion of the embankment, approximately 850 feet long.
- Construction of an enlarged embankment at each end of the earth reinforced structure to raise the crest up to the desired elevation.

The rehabilitation plan addresses the following areas:

- Internal seepage control
- Feasible and economical embankment construction
- Crest road design
- Erosion control on the upstream face
- Materials selection
- Embankment stability

DRAINAGE CONTROL

Impervious Barrier

The pool elevation will be raised from the existing elevation of 6712.8 to 6721 feet NGVD. This increase in head has the potential to create an entire new seepage pattern through the existing embankment. The result would be to raise the phreatic surface throughout the embankment. Raising of the phreatic surface would create unacceptable stability factors of safety. The combination of an addition to the dam crest elevation and an increase in the phreatic surface in the embankment would be unacceptable unless the phreatic surface could be controlled to maintain stability.

The design feature which will control the phreatic surface through the embankment is an impervious barrier trench located along the main portion of the embankment as shown in Appendix D-3. This barrier trench would consist of an impervious flexible membrane buried to a depth of approximately 24 feet below the proposed crest elevation. A 12-inch diameter drain pipe and a high capacity drain fill would be placed at the lowest point of the impervious membrane. The purpose of this drain is to prevent an increase in the phreatic surface on the downstream side of the impervious barrier.

This proposed system was evaluated using a finite element computer model to represent flows through the embankment. Results of the computer modeling indicate that the phreatic surface will not raise above the elevation used to evaluate stability of the embankment except at the upper most elevations. At the barrier trench the phreatic surface will be about two feet higher than the phreatic surface used in the original stability analysis. This is because the trench is downstream from the location originally conceptualized. This higher phreatic surface was used in the final stability calculations. Results indicate stability is adequate. Stability is discussed later in this section.

Embankment Section

Rehabilitation in the dike portion (embankment beyond ends of earth reinforced structure) of Middle Creek Dam will consist of raising the crest elevation by placing new fill over the downstream face of the existing embankment. Crest alignment for the new embankment will be approximately parallel to the existing embankment with slightly wider radius.

The process of constructing this embankment will consist of excavating the upper three feet of the existing material off the embankment then placing the new fill. The new fill will include an impervious zone which will tie into the existing impervious upstream section of the existing embankment. A more pervious embankment zone will be constructed on the downstream side. Internal seepage will be controlled by a filter drain located at the toe of the existing embankment.

The new filter will be approximately 9 feet wide and 5 feet deep at the toe of the existing embankment below the new fill. There will be a drain pipe in the gravel filter section to collect seepage.

Embankment Drains and Filter Design

New drains will be installed in the abutments and under the Earth Reinforced Structure (ERS). A barrier trench drain as discussed previously will be utilized to lower the phreatic surface under the upstream portion of the ERS. An "ERS Foundation Drain" will be placed under the downstream edge of the ERS.

The ERS foundation drain will be utilized to pick up any water that enters the ERS either from surface infiltration or through the upstream face. Both drains will drain laterally in both directions from the center of the embankment toward the abutments. The barrier trench drainage will be collected at each abutment by non-perforated collector pipes that will direct flows toward manholes situated on the downstream side of the dam crest in each abutment. The ERS foundation drain will drain directly into the manholes. Configuration of the inlets to the manholes is such that flows for each of the drains can be monitored.

All drains within the embankment will consist of varying diameters of factory slotted AWWA C-900 Class 200 pressure pipe with drain gravel envelopes. The abutment drains that have only small over burden pressures will consist of perforated Polyethelene tubing with drain gravel envelopes.

The majority of the gravel envelopes for the drains will consist of Grade B drain/filter gravel. The gravel for the barrier trench drain will consist of a washed Grade A drain gravel. A filter fabric will be required to prevent potential piping of the existing embankment soils into the washed Grade A drain gravel of the barrier trench.

Standard gravel filter design criteria has been utilized in selecting compatible filter/drain gravel, pipe perforations and filter fabric.

Gradation of the Grade B drain/filter gravel was determined using the following criteria:

D_{15} filter $\leq$ 4 D_{85} soil
D_{15} filter $\geq$ 5 D_{15} soil

As presented by (Cedergren, 1977) and (Jansen, 1988) representative gradations of Zone I, Zone II and the abutment soils were utilized in the design. The design calculations are presented in Appendix D-5. To further reduce the risk of piping within the embankment, the Zone I material gradation has been specified within ranges to ensure a self filtering soil (Jansen, 1988).

The final selection of the filter fabric will be determined after the completion of hydraulic conductivity tests (HCR) now being conducted on representative soil samples and a candidate filter fabric. A preliminary selection of the fabric has been accomplished utilizing filter criteria for geotextiles (J.P. Giroud, 1981) and filter fabric selection USBR criteria (Jansen, 1988).

EMBANKMENT CONFIGURATION

The design is based on the assumption that the primary source for materials for construction rehabilitation will be from the excavation for the new auxiliary spillway and Borrow Area A. Results from the exploration holes in the auxiliary spillway area confirm that the borrow area consists of a variety of materials ranging from clay to clean gravels. The predominant material is a clay gravel. Based on the test results, it appears that an impervious section consisting of well controlled clay material and a large section consisting of clay gravel appears viable.

Aggregate for gravel filters and drains, bedding material and road sections will come from Borrow Area A located just upstream of the auxiliary spillway area, the auxiliary spillway excavation, or they may come from off-site sources of the contractors choosing. The borrow appears to be a relatively clean gravel but is limited in volume. High capacity drain gravels will likely come from an off-site source or processing local material may be cost effective.

SEEPAGE THROUGH THE EMBANKMENT

The existing Middle Creek Dam embankment is stable under steady state seepage conditions. The calculated factor of safety is 1.67. The location of the phreatic surface through the embankment has been identified by monitoring, using the piezometer and monitoring tubes located in the embankment. Stability is based on many factors, of which one of the most important is the ground water level (phreatic surface) through the dam. If the phreatic surface is increased through the embankment, the result is decreased stability.

Rehabilitation of the facility includes an increase in the pool elevation of about 10 feet. This increase will cause an increase in the phreatic surface in the embankment.

A minimum acceptable factor of safety (stability) is 1.50. The increase in the phreatic surface could cause a decrease in the factor of safety below 1.5. To maintain stability, the phreatic surface should be controlled near the existing elevation. A system consisting of an impervious barrier trench and seepage collector drain has been designed to control the internal seepage and keep the phreatic surface low. This system is shown in Appendix D-3 which is titled Barrier Trench and Earth Reinforced Section.

The barrier trench is constructed of a layer of 36 mil Hypolon liner extending from the base of the earth reinforced wall to a depth of about 24 feet below the crest or about 14.3 feet below the proposed normal pool. The trench is backfilled with clayey gravel having low permeability. There is a 12 inch diameter collector drain at the bottom of the trench.

In the embankment area on the right abutment the phreatic surface will increase in elevation through the embankment. Seepage will be controlled by a drain located at the toe of the existing slope.

Engineering analyses to evaluate the potential for the barrier trench system to control seepage is detailed in the Seepage Analysis in Appendix D-1. Previous seepage analyses have been reported in the Geotechnical Investigation, April 1984.

BENTONITE LINER AND SINK HOLES

There is an existing bentonite liner located on the left abutment upstream of the embankment. The bentonite layer is from 1 to 9 inches thick and is overlain by about 3 feet of gravel. The liner was constructed in 1956 for the purpose of controlling seepage through the left abutment. This liner is shown on Sheet 18 of Appendix A-1.

Several sink holes have developed above holes in the liner. These holes are located near the groin area of the embankment with the abutment. HKM made test pits exploration in the area to investigate the cause of the sink holes. Findings from these test pits were reported previously (HKM 1986). Although the test pits were backfilled, the sink holes still exist (preconstruction). Additionally, the test pits have the potential to contribute to the sink hole problems.

The impervious liner over the abutment in the area of the sink holes will be reconstructed with 3 feet of compacted earth lining. This new lining should stop further development of the sink holes.

The proposed new embankment will cover a portion of the area presently covered by the existing bentonite liner. This bentonite material has very low shear strength. To maintain embankment stability, the bentonite liner will be removed and replaced with a compacted earth lining.

Replacement of the bentonite liner with the compacted earth liner will include all of the existing liner area above elevation 6680 from the upstream toe of the embankment at least 100 feet upstream. This encompasses the sink hole areas as well as the foundation area of the proposed new embankment.

STABILITY

Stability analyses were performed to determine the factor of safety against failure for the maximum embankment section. Physical and engineering soil properties were determined for all materials involved.

The downstream slope stability was computed using the UTEXAS2 (University of Texas Analysis of Slopes - Version 2) computer program (Wright, 1987). Slope stability calculations were performed for two phreatic surface conditions that were developed in the seepage analysis (Appendix D-1). The first phreatic surface is based on the barrier drain functioning and the other phreatic surface is based on the barrier drain failing. The Spencer Method was utilized to compute safety factors.

The minimum factor of safety slip circle is located high on the embankment above both phreatic surfaces considered. A second slip circle located low in the embankment has a very similar factor of safety. The computer printouts for the stability analyses are provided in Appendix D-6. The calculated minimum factors of safety are:

	Upper Circle	Lower Circle	Design Standard
Drain Working	1.5	1.55	1.5
Drain Failed	1.5	1.50	1.5

The upper circle stability calculations contain warning messages that side forces on some of the slices are applied below the shear surface. A review of this condition found that the modeling of the soil reinforcement causes this computation difficulty. This occurs on only three of the 25 slices. A sensitivity analysis was performed by varying the reinforcement strength. The impact of this computation difficulty was found to be negligible.

A slip circle that would coincide with the barrier membrane was also evaluated. The membrane was modelled as a thin layer of material with no cohesive strength and no friction angle. The resulting factor of safety was 1.60.

The upstream slope stability was computed using the COE Computer Program, "Standard Method of Slices". Modelling the sudden drawdown condition, the calculated minimum factor of safety is 1.17. The design standard is 1.2. The computer printout of this analysis is also included in Appendix D-6.

MONITORING

A plan was developed to monitor the long-term integrity of the embankment. The plan utilizes monitoring wells to measure the piezometric surface in the embankment and foundation, measurement of flow in the drains to determine seepage volumes, monitoring points and slope inclinometers to measure deformation, and a strong motion seismograph on the embankment to measure the response to seismic events.

Details of the monitoring plan are included in Appendix D and the drawings. Instructions for the monitoring plan are included in the operation and maintenance manual.

RIPRAP

Riprap will be removed to approximately Elevation 6720 feet. The riprap will be stockpiled during construction for later use on the upstream face. Riprap will be placed along the entire length of the upstream face. Additional riprap will be required.

Riprap will be obtained from a basalt and andesite talus slope approximately four miles from the dam. The riprap sizing for the face of the dam was determined utilizing Army Corps of Engineers Earth and Rockfill Dam Design Considerations (EM 110-2-2300). A significant wave height (Hs) of 2 feet and specific gravity of 2.8 were utilized in the sizing computations. The design gradation for the riprap is as follows:

Max Size = 24" = 156 lbs.
Average Size = 10" = 34 lbs.
Minimum Size = 4" = 6 lbs.

L.A. Abrasion, specific gravity and absorption tests have been conducted on the riprap material. The test results indicate the basalt and andesite to be of adequate quality. Test results are presented in Appendix C. The design sizing for the face of the dam is conservative in that the average size of the existing riprap on the dam face is approximately 7 inches in diameter with a maximum size of approximately 15 inches. The existing riprap is basalt and is in very good condition.

Riprap of larger size (36-inch maximum, 18-inch average) was selected for the stream channel immediately below the outlet. Cobble riprap which will be obtained from processing excavated material is utilized in areas of light erosion potential.

The existing riprap is approximately 2.5 feet thick and is underlain by sandy and silty gravel riprap bedding material. The new riprap section to be added to the embankment will consist of approximately a 2.5 foot thick layer with 12 inches of gravel riprap bedding. Where the riprap is placed horizontally in the areas on the right abutment the layer will only be two feet thick underlain by 12 inches of gravel bedding.

E. EARTH REINFORCED STRUCTURE

An earth reinforced structure was selected as the preferred alternative design concept to raise the crest elevation of the main portion of the embankment. A discussion of other alternatives is presented in the 1984 report (HKM, 1984). This system consists of raising the crest by constructing vertical retaining walls supported by strap or wire grid anchors buried in the wall backfill.

A roller compacted concrete (RCC) alternative was discussed at the December 1988 agency review meeting. A value engineering comparison of the RCC alternative and the selected alternative is presented in Appendix E.

Several alternative methods of constructing the earth reinforced structure were evaluated. The evaluation criteria included the following concepts. The system must:

- Rise near vertically and be supported by buried anchors in the backfill behind the wall
- Be capable of withstanding horizontal accelerations of up to 0.47 gs without significant damage
- Be highly flexible to accommodate settlements of up to 1 foot, if necessary

Earth reinforced systems designed by Reinforced Earth Company and VSL Corporation are capable of meeting the established criteria. These companies were invited to prepare final drawings and specifications for construction. Design calculations provided by VSL Corporation and by Reinforced Earth Company are included in Appendix E.

The structure is 37.5 feet wide with the upstream wall about 13 feet high and the downstream wall about 19 feet high. There is a 28-foot wide roadway (guardrail to guardrail) on the crest with a 3.0 foot walkway on the reservoir side. The crest road is designed with a temporary gravel surface which will ultimately be paved by the USFS.

The road is bordered by precast concrete traffic barriers. There is a handrail at the top of each wall. A concrete splash cap is designed on the upstream face to aid in wave deflection.

REINFORCED EARTH SYSTEM

The face of the walls are 5½-inch-thick concrete panels for the Reinforced Earth Company system and 6½-inches for the VSL Corporation system. The concrete surface will be smooth and will be the natural concrete color, gray.

The upstream face of the retaining system is designed to be watertight. Additionally, the interior earth fill is designed to act as a seepage control system to handle percolation from the surface and seepage through the upstream wall if leakage would develop as a result of wall movements or defects.

The gravel road surface is sufficiently pervious to reduce the potential for surface runoff over the concrete face. After paving some surface runoff may run down the face of the concrete panels. This should not create a structural or aesthetic problem.

The internal drain system proposed by the Reinforced Earth Company includes a free draining zone 3-feet wide, adjacent to both walls and extend up to within 2-feet of the surface. A 6-inch diameter drain pipe is located near the wall footing of the downstream wall for the purpose of collecting all seepage in the structure. The drain pipe will be surrounded by drain gravel to aid in seepage collection and transportation.

The VSL system has a free draining zone about 2½ feet wide down the center of the fill between the two walls. There is a 1-foot thick drain across the top, full width, and sloping to the vertical drain in the center. A 6-inch diameter drain pipe is located near the wall footing of the downstream wall for the purpose of collecting all seepage in the structure.

A thin impervious soil zone 1 foot thick is designed for both systems at the contact of the structural backfill with the existing embankment. The purpose of this zone is to help control internal seepage in the structure by diverting it to the collector drain.

GATE TOWER EXTENSION AND WALKWAY

An extension to the existing gate tower is included in this project to accommodate a higher pool level in the reservoir. A new walkway has been included to provide access from the top of the new earth reinforced structure to the gate tower. The tower has been raised approximately 6 feet while the catwalk is approximately 8 feet above the elevation of the original.

The tower extension involves demolition of the original wood framed roof, construction of 12 inch reinforced concrete walls on top of the existing tower and construction of a new wood framed roof. The inside dimensions of the new section of the gate tower match the original tower. The new walls are 3 inches thicker than the original and are designed with an overlap over the original to seal the tower from water and weather. The new walls are reinforced with 2 layers of steel and are doweled into the original walls.

The new timber roof is patterned after the original roof with the same access to accommodate the existing interior ladder. The roof is covered with a standing seam metal roofing to provide durability and low maintenance.

Design of the tower extension was done by ultimate strength design procedures, ACI Codes and USBR Standards for minimum reinforcement. Material strengths used for design included 4,000 psi, 28 day compressive strength for the concrete, 60,000 psi yield strength for the reinforcing and design values for No. 2 Douglas Fir-Larch as published in the National Forest Products Association. The analysis of the tower evaluated three conditions:

- Dead Loads
- Dead Loads Plus Snow
- Dead Loads Plus Seismic

The access walkway to the tower consists of structural steel framing supported on the gate tower and a concrete pier. The walkway spans approximately 47 feet from the pier to the tower. A 4 foot cantileaver extends from the tower toward the reinforced earth section. The walkway does not attach to the reinforced earth section to allow for differential movements and expansion/contraction. The walkway has a non-slip metal plank decking and aluminum handrails. The design of the walkway conforms to the American Institute of Steel Construction Design Standards.

The walkway is designed for ASTM A-36 steel (fy==36,000 psi) and a live load of 85 pounds per square foot or a snow load of 135 psi.

F. PRINCIPAL SPILLWAY

The principal spillway consists of a labyrinth weir crest followed by a baffled apron drop, an intermediate earthen channel and another baffled apron drop. The auxiliary spillway crest is 2 feet above the labyrinth crest and the principal spillway is designed to pass 1200 cfs before the auxiliary spillway operates. The 500-year flood is estimated to be 1000 cfs. The maximum flow in the principal spillway during the PMF is 3250 cfs.

HYDRAULICS

Labyrinth Crest

The labyrinth crest design will be the same as presented in the loan application report (HKM, 1987). The crest elevation is set at 6721.0 feet NGVD. Upstream from the crest a concrete slab will slope down at 3H:1V to provide protection from ice loading on the structure. The sloping ramp will provide a surface for ice to ride up and not allow it to push against the vertical wall face. The labyrinth will consist of one cycle extending out approximately 69 feet to the apex. The labyrinth is not symmetrical. The wingwall on the east side of the spillway chute extends 8 feet further upstream than the wingwall on the west side. Therefore, the length of the crest on the east side will be 67 feet and the length on the west side will be 75 feet. The hydraulic analysis (Appendix F-5) is based on a 140 ft. crest length. The spillway chute is 37 feet wide. The point of the apex will be squared off to allow for concrete forming considerations. Hydraulic design of the labyrinth followed USBR criteria (Houston, 1982). The crest shape was selected for ease of construction. Protrusions were placed on the crest on each side of the labyrinth to aerate the nappe.

An orifice restriction will be included to limit flows in the principal spillway during extreme flood events. This orifice will consist of a rectangular opening 6.5 feet high across the entire 37 foot spillway chute width. The hydraulic control shifts from the spillway crest to the orifice at about 2000 cfs.

The lack of symmetry in the labyrinth may cause flows to be non-symmetrical in the spillway. At low flows the baffled apron will cause the flow to redistribute across the spillway. At higher flows, control shifts to the orifice which is symmetrical.

Upper Baffled Apron Drop

The upper spillway chute will be a baffled apron drop in the same location as the existing principal spillway. The baffled apron design was selected because it is not dependent on tailwater depth, it operates well at flows in excess of the design flow, and it dissipates energy throughout its length which keeps velocities much lower. USBR experience has shown baffled aprons to operate at as much as twice the design discharge for short periods without adverse effect (USBR, 1978b; Rhone, 1977). Therefore, the design discharge was set at one-half the PMF discharge in the upper spillway. It is recognized that some damage may occur during flows in excess of the design discharge, but this damage would not cause a failure of the dam embankment. USBR guidelines were utilized in designing the baffled apron (USBR, 1987; USBR 1978a; USBR, 1978b). The details of the hydraulic design are included in Appendix F-1.

The hydraulic forces on the blocks were computed based on flow at critical depth. At the PMF discharge of 3250 cfs, the critical depth is 6.2 feet and the pressure on the blocks is 490 pounds per square foot.

Channel

The intermediate earthen channel between the two spillway chutes is designed to control flows up to 1500 cfs maintaining a velocity less than 5 feet per second. For flows in excess of 1500 cfs, the dike across the meadow will be overtopped and this flow will follow the present spillway channel.

The crest of the lower spillway chute is set at elevation 6683.3 feet NGVD. This elevation was established to keep the height of the meadow dike to a minimum while maintaining velocities less than 5 feet per second in the channel. The channel between the chute and the meadow has a 40 foot bottom width and is at a uniform slope from the meadow to the chute. The cut slopes are set at 2.5H:1V. The excavation is needed to provide a positive channel to the chute.

A training dike is needed south of the lower chute entrance to ensure that flood flows do not bypass the lower chute. The top of this dike will be set to provide three feet (including topsoil) of freeboard during the PMF. The side slopes will be 2.5H:1V with one foot of topsoil placed over the compacted embankment.

The excavated channel will be lined with thick compacted earth lining for a distance of 30 feet upstream from the lower chute. This lining will reduce the seepage to the chute foundation. The lining will be covered with cobble erosion protection.

The dike across the meadow will have a crest elevation matching the water surface at a flow of 1500 cfs. The crest will be approximately at elevation 6692.0 feet NGVD which results in a dike 6 feet high. The side slopes will be 3H:1V. The downstream slope will be topsoiled and the upstream slope will have cobble erosion protection. The crest will not be topsoiled to provide a more reliable control elevation.

Excavation is needed in the channel between the meadow and the upper spillway chute to maintain velocities below 5 feet/second. The minimum channel bottom width will be 40 feet with a 2H:1V slope on the west side and a 2.5H:1V slope on the east side. The east side slope is flatter to avoid undercutting the hillside and creating slope stability problems. The bottom of this channel will be approximately at elevation 6687.0 feet NGVD.

The hydraulics of the spillway channel were analyzed using the COE HEC-2 computer program (COE, 1984). The split flow routine was utilized to model the effects of overtopping the meadow dike. Manning's roughness coefficients of 0.04 and 0.10 were utilized for the main channel and over bank flows. It will be necessary to remove trees from the channel up to elevation 6690 feet NGVD to provide a clear flow path. The 0.04 coefficient represents brush with no trees and the 0.10 coefficient represents heavy timber. The contraction and expansion loss coefficients were set at 0.1 and 0.3 for gradual transitions and at 0.6 and 0.8 for abrupt transitions.

The split flow analysis shows that during the PMF, approximately 1800 cfs will flow down the lower chute with the remaining 1450 cfs flowing over the dike and down the present spillway channel. It is anticipated that the dike will fail if it is overtopped which will allow more flow to be directed down the present spillway channel. The printout from the HEC-2 analysis is attached in Appendix F-4.

Lower Baffled Apron Drop

The lower spillway chute serves to carry flows from the meadow area down to the stream channel immediately below the dam. This chute will also be a baffled apron drop. The design flow is 1000 cfs and the PMF flow in the lower chute is 1800 cfs.

Various chute widths were evaluated and 25 feet was selected as the most economical width that provides good operating characteristics. The details of the hydraulic design are included in Appendix F-2.

STRUCTURAL

Both the upper and lower principal spillway structures were designed using ultimate strength design procedures for concrete, ACI codes and USBR standards for minimum reinforcement. Material strengths for the design included 4,000 psi, 28 day compressive strength for the concrete and 60,000 psi yield strength for the reinforcing steel. A stability evaluation was performed for each structure which included hydrostatic uplift, static weight, hydraulic forces from water flowing in the chute and an equivalent static earthquake load. The analysis evaluated three conditions which consisted of:

- Dead Loads
- Dead Loads Plus PMF Forces
- Dead Loads Plus Earthquake Forces

The analysis resulted in providing drilled concrete filled soil anchors and shear lugs under the floor slab to improve sliding resistance.

Various factors of safety (FS) were used in the analysis and design as follows:

FS = 1.50 for DL
FS = 1.15 for DL + PMF
FS = 1.15 for DL + Earthquake (EQ)

Anchor capacities were calculated using a FS = 1.5. The net anchor capacities were applied to calculate the structure FS thus compounding the FS. For a more complete discussion on the stability analysis see Appendix Section F-3.

The upper principal spillway structure is being constructed at the same location as the existing concrete chute. The inlet crest elevation is being raised above the existing crest by approximately 10 feet. As such the labyrinth weir is being constructed on a compacted fill. Because of the fill the inlet has been divided into sections approximately 20 feet long to account for possible settlement. Portions of the existing spillway and footings are required to be left inplace through the orifice section. Bridges are being carried on the sidewalls in this section and the new bearing walls are to extend to the existing footings which are expected to be stable and not as susceptible to settlements as would new footings bearing in the shallower fill material.

The lower portion of the existing chute is being removed completely along with sections of the upstream wing walls. The new structure has control joints at strategic locations to allow movement between the various sections.

GEOTECHNICAL

The baffled apron drop structures are relatively light weight. Net soil pressure is not expected to exceed 500 pounds per square foot. Vertical soil bearing pressure is not a major concern.

A 6-inch thick layer of uniformly graded gravel is spread throughout the foundation area. This gravel will provide a uniform distribution of pressures and good under-drainage.

Seepage Control

A flownet was developed for the slopes supporting the baffled apron drop structures. Results indicate that about 3 feet of hydrostatic pressure could develop at the toe of the upper drop structure. This uplift potential will be controlled by burying the lower end of the structure, installing a large drain section under the toe of the slab and providing soil anchors. Additionally, the floor of the upper structure is underlain by 3 rows of 4-inch diameter lateral pipe drains which carry seepage to two 4-inch diameter collectors drains located under the wall footings and running parallel to the footings.

Seepage calculations indicate the total seepage into the foundation area of the upper baffled drop structure will be less than 20 gallons per minute. This value is based on a permeability value of 450 feet per year and a factor of safety of 3 or greater. Additional seepage is anticipated in the hillside east of the structure with a PVC weep extending into that area.

Analyses indicate that some hydrostatic pressures could develop under the lower baffled drop structure with rapid fluctuations in the stream level. Additionally, there is a potential for isolated springs to develop under the floor slab, however, ground water does not appear to be a major problem.

The lower baffled drop structure is also underlain by 6 inches of gravel. Eleven 4-inch diameter lateral drains are spaced on 12-foot centers under the floor. There is a 4-inch diameter collector running parallel to the chute on each side of the structure.

The drain system was designed to carry a minimum of 150 gallons per minute in each drain (each side of chute). Calculations are based on a permeability value of 2300 feet per year and a factor of safety of at least 3.

Lateral Pressures

An equivalent fluid pressure of 45 pounds per cubic foot was used to calculate lateral soil pressures for the baffled drop structures. This value is considered conservatively high for static conditions.

The lateral pressures on the walls of the drop structure will be increased during earthquakes. A maximum peak acceleration of 0.22 g's was selected as a minimum design criteria. The analysis describing the evaluation of the peak horizontal acceleration is included in the report Geotechnical Investigation Middle Creek Dam, April 1984.

Many walls which are adequately designed for static earth pressure will automatically have the capacity to withstand earthquake ground motions without requiring special seismic provision. This depends on the conservatism used in the static pressure design, an acceptable factor of safety and the backfill material. In review, the criteria used in the static design is as follows:

Equivalent fluid weight = 45 pcf
Angle of friction of backfill = 30°

For the occasional, temporary forces due to earthquakes, it is reasonable to accept a lower factor of safety of 1.15. Additionally, the peak acceleration occurs for only one instant during the earthquake and thus does not have sufficient duration to cause significant wall displacement (Seed and Whitman, 1970). Applying these considerations and the static design criteria, analyses were made to determine what horizontal acceleration the structures could withstand. Calculations based on Seed and Whitman, 1970 suggest that the structures are actually designed to withstand peak horizontal accelerations of about 0.25 g's which is greater than the minimum criteria of 0.22 g's set for this project.

TRASH BOOM

A trash boom upstream of the upper principal spillway is included in this project. The trash boom consists of foam filled 24 inch diameter steel pipes attached to a 5/8 inch diameter steel cable. The foam filled pipes are 20 foot long sections attached to the steel cable with chain. The cable is anchored at each end and at a center point with cast-in-place concrete deadmen. The trash boom is designed to float on the reservoir surface approximately 25 feet from the crest of the spillway inlet.

The design loads for the trash boom were established using procedures contained in a "Report for the Canadian Electrical Association" prepared by Shawingan Consultants Inc., Montreal, Quebec, Canada, November 1982. In addition a technical report REMR-HY-3, "Elements of Floating Debris Control Systems" by Roscoe E. Perham of the Department of the Army, US Cold Regions Research and Engineering Laboratory was referenced for details and construction requirements. The design established for the trash boom was 25.4 pounds per lineal foot. The steel pipes, labels and deadmen were sized for a minimum of a 2:1 safety factor in resisting the design load.

G. AUXILIARY SPILLWAY

The auxiliary spillway will consist of an earthen channel with a concrete sill wall to provide grade control at the crest. The auxiliary spillway crest is at 6723.0 feet NGVD which is 2 feet above the new principal spillway crest. The principal spillway will pass about 1200 cfs before the auxiliary spillway operates. Considerable damage and erosion will occur if this spillway operates, but the damage would be minor compared to that caused by a dam breach.

The auxiliary spillway will have a circular crest (in plan view) with a 530-foot length and a horizontal radius of curvature of 494.5 feet. The channel below the crest transitions to a 70-foot bottom width. Channel side slopes vary between 2½H:1V and 8H:1V to provide a more natural appearance. Flow from this excavation spills over the existing main access road into the depressed area below. Excavation is included to provide a lower channel which directs water to the steep slope down to Middle Creek. A small dike along the right side of the lower channel keeps water away from the toe of the dam. The main access road to the reservoir will be routed to follow the upper channel to the crest of the dam.

The material excavated to create the auxiliary spillway will be utilized for fill on the project. Sorting and processing of this material is anticipated. Topsoil will be stripped and stockpiled and processing will require removal of oversized cobbles at a minimum. Oversized cobbles will be utilized for Class C riprap. More material will be excavated than is required in fill. Therefore, waste areas have been included in the design. A borrow area has also been identified to provide additional granular material if needed.

HYDRAULICS

The hydraulics of the upper channel were analyzed using the COE HEC-2 Computer program (COE, 1984). The channel profile was established to provide the minimum velocities in the channel that would maintain critical flow at the crest. The results of this analysis are included in Appendix G-1. The hydraulics of the lower channel were previously analyzed in the Feasibility Study (HKM, 1985).

STRUCTURAL

The auxiliary spillway will have a circular crest with a concrete sill wall to provide grade control. The concrete wall is a buried 4-foot high by 8-inch thick section with a 3-foot 2-inch by 10-inch footing. The wall is designed as a cantilever retaining wall that will stand if all the material is removed from the downstream face.

The wall was designed using ultimate strength design procedures for concrete and ACI codes. Material strengths for the design included 4,000 psi, 28-day compressive strength for the concrete and 60,000 psi yield strength for the reinforcing steel. A stability analysis revealed a FS of 2.17 for overturning and 1.33 for sliding.

GEOTECHNICAL

The auxiliary spillway will be an excavated earthen channel. The soils in the area are glacial till with particle sizes ranging from clays to boulders. A day-use area with a road, parking areas, boat ramp, and picnic tables will be located in the auxiliary spillway. Control of the crest elevation will be provided with a buried concrete wall.

Typical sections of the spillway crest are shown in Appendix A-1.

The concrete sill will provide positive grade control for the crest and will also serve as a positive cut-off along the crest. This wall is designed as a cantilever retaining wall that will stand if all the material is removed from the downstream face of the wall. The footing is below the anticipated frost depth of 4.5 feet.

The day-use area access road will be immediately upstream of the concrete sill. This gravel road will have a top width of 25 feet with a 2% cross-slope away from the crest to provide surface drainage. A parking area and boat ramp were designed for the spillway area.

The excavation for the auxiliary spillway will provide the primary borrow source for the project. The volume of excavation is expected to be 77,500 cubic yards. It is anticipated that waste will vary between 15 and 30 percent. The waste is a combination of surface stripping, oversized rock and soils with an excessive amount of fine grained material. It is estimated that about 9 percent shrinkage will result from compaction of the material into an engineered fill.

H. ROADS

ALIGNMENT

The proposed roadway alignment will generally follow the existing alignment except on the west side of the dam. Raising the crest of the dam would result in undesireable grades on the existing road alignment in this area. Therefore, the roadway on the west side of the dam will be realigned to generally follow the alignment of the auxiliary spillway to provide more acceptable grades.

SPEED

The design speed for the roadway within the project limits is 20 mph. However, site conditions limit the design speed to 15 mph on both ends of the dam due to horizontal curvature. The design vehicle is a log truck.

SURFACE

While the roadway to be constructed with the dam rehabilitation will have a gravel surface, it is anticipated that the road will be paved by the USFS with an asphalt concrete surface in the near future. Based on coordination with the USFS, the top width of the gravel surface to be constructed at this time will generally be 26 feet except where wider sections are required due to curve widening or guardrail placement. This will provide for a future paved roadway with 11 foot traffic lanes and 1 foot shoulders.

TOLERANCES

The construction documents allow for the same tolerances as used by the USFS in construction of Hyalite road. These tolerances are as follows:

ITEM	TOLERANCE CLASS[a]
Roadbed Width (Feet)	+1
Subgrade Elevation (Feet)	±0.2
Centerline Alignment (Feet)	0.5
Slopes, Excavation and Embankment (Percent Slope)[b]	±5

[a] Maximum allowable deviation from construction stakes and drawings.

[b] Maximum allowable deviation from staked slope measured from slope stakes points.

GUARDRAILS

The proposed roadway alignment was reviewed to determine if guardrail installation is warranted. Traffic barriers will be required across the earth reinforced wall section and on the structure over the principal spillway. Based on a cost effective selection procedure, it was determined the guardrail should also be installed along the upstream slope of the dam.

GEOTECHNICAL

Two California bearing ratio (CBR) tests were conducted on borrow materials located in the emergency spillway area to determine subgrade strengths. Samples were selected from soils having the highest plasticity indices. These soils represent the worst possible conditions found in the spillway area. CBR values determined for these soils were 4 and 5. These test results are shown in Appendix C-1. Since these soils will be incorporated into the subgrade along with higher quality material, which is also located in the spillway area, CBR values are felt to be overly conservative and do not yield a reasonable representation of the strength of the soils in the subgrade. A higher CBR valve of 6 was chosen to represent the subgrade strength. This value is slightly conservative compared to the value chosen by the USFS (CBR = 7) for the road section immediately to the north of the spillway area.

A pavement design was selected using the Montana Department of Highway's Design Procedure (MDOH, 1982). A resistance value of 14 was used. This value corresponds to a CBR of 6 (Asphalt Institute, 1983). The equivalent daily 18^k Single Axle Load (18^k EAL) was calculated using the total 20 year 18^k EAL number determined by the USFS for the road section between mile posts 8.39 and 9.2. This number, 8,454, was reduced to the daily 18^k EAL by dividing by 20 to yield the yearly 18^k EAL. The yearly number was then divided by 274 days (9 months) to yield the daily 18^k EAL which is 1.5. Nine months was used in order to yield a conservative 18^k EAL. Currently, the road to Middle Creek is only opened about nine months out of the year.

The following flexible pavement structure will be used for the road:

Material	Thickness (inches)
Asphaltic Concrete, Grade B (MDOH)	2
Crushed Top Surface, Grading D (USFS)	3
Pit Run Gravel	7

This pavement design is based on the assumption that the road will be paved in the near future. It is recommended that the granular base materials be paved within one year of construction. If pavement of the road is not accomplished within one year, it is recommended that two inches of crushed top surfacing be added as a wearing course to help prevent degradation of the road surface. Other details of the roadway design can be found in Appendices H-1 and H-2.

I. BRIDGES

STRUCTURAL

Two bridges are included in this project that cross the principal spillway. They consist of a vehicle bridge with a 28 foot clear roadway width (guardrail to guardrail) and a pedestrian bridge with a 4-foot 6-inch walkway width. The bridges span the horizontal orifice section of the upper spillway structure. The bridges are skewed with the principal spillway structure at 11°20' to accommodate using the existing footings for the new structure. The bridges are composed of precast prestressed channel beams that are supported on the side walls of the concrete chute (Appendix I-1). Various alternatives were evaluated for the pedestrian bridge including concrete, timber and steel structures. A comparison of 4 alternatives is presented in Appendix I-2. A precast prestressed section similar to the vehicle bridge was selected as the best alternative.

The bridges are designed in accordance with the AASHTO "Standard Specifications for Highway Bridges" 1983 Edition. Design loads are as follows:

VEHICLE BRIDGE

AASHTO HS20-44 Standard Truck Load
3 inch Future Asphalt Wearing Course
135 PSF Snow Load

PEDESTRIAN BRIDGE

85 PSF Live Load
135 PSF Snow Load

The bridge guardrails are precast concrete barrier rails that bolt through the deck of the bridge. The rails conform to the AASHTO requirements for bridge rails. Metal beam approach rails are attached to each corner and conform to the USFS Standards. The hand rail for the pedestrian bridge is located on the upstream edge only and is composed of 1½-inch diameter aluminum pipe. The hand rail conforms to AASHTO requirements.

The precast bridge beams are 6-foot wide sections with two legs that are 4-foot on center. The legs of the beams have been offset 6 inches from the centerline of the beam to provide a 1.5 foot deck extension along one side to mount the guard rail. All the beams are the same shape to allow for only one form set up by the fabricator in an effort to keep costs to a minimum.

GEOTECHNICAL

The existing bridge over the principal spillway at Middle Creek Dam is supported by the chute walls which are placed on a conventional spread footing at a depth of about 20 feet.

An analysis was performed to evaluate bridge foundation systems. Considered were conventional spread footings or a deep foundation system consisting of either piles or caissons. It was determined that the new bridge could be supported by the new spillway walls which would be placed on the existing footings provided the resulting settlement is acceptable.

Calculations were performed to evaluate settlement potential for the new bridge and spillway. Settlement calculations were based primarily on a standard penetration resistance test performed in the exploration holes near the bridge.

Loads on the bridge and spillway include the following:

1. The weight of additional embankment to raise the crest elevation;
2. The weight of the new bridge which is heavier and wider than the original bridge; and

3. The weight of the new spillway which includes additional concrete and about 6 feet of earthfill to raise the floor slab elevation.
4. Live loads from snow, traffic, and wind.

Settlement calculations indicate that the bridge may settle as much as 1 inch with approximately ½ inch resulting from the weight of the new fill in the embankment and spillway and the remainder from the combined live and dead loads on the bridge. It is estimated that less than ½ inch of differential movement will occur across the floor slab of the spillway; induced by movement of the wall supporting the bridge abutments.

J. RECREATION FACILITIES

Recreation facilities have been designed for the Blackmore, Hood Creek, and Chisholm areas surrounding the reservoir. Designs reflect the following information:

- Conceptual design drawings provided by the USFS.
- Standard design details provided by the USFS.
- Field review with USFS personnel.

For specific details, refer to the project drawings and specifications in Appendix A.

K. GRAYLING SPAWNING MITIGATION STRUCTURE

A simple log structure was constructed in the fall of 1988 to allow for operation of a side channel of the West Fork of Hyalite Creek to replace Arctic Grayling spawning grounds that will be lost after raising Middle Creek Dam. Desirable depths and velocities have been achieved in a large area of the side channel for a wide range of flow conditions. Under flooding conditions velocities slightly exceed erodible velocities for clear water, however, they are below erodible velocities for waters transporting colloidal silts. Therefore, a simple, inexpensive, visually acceptable design as constructed should perform acceptably under the full range of anticipated flow conditions. Use of a gated structure was not recommended for numerous reasons including the need for an operator; the expense of continual maintenance; problems with debris, ice, fish passage; appearance; and a large upstream pond.

The performance of the side channel has been measured each year since the log structure was constructed. Appendix J contains design and performance information.

REFERENCES

Asphalt Institute, 1983 - Asphalt Technology and Construction Practices Institutes Guide (ES-1). "Structural Design of Asphalt Pavements", Page J15

Cedergren, Harry R. 1977. Seepage, Drainage, and Flow Nets. 2nd Edition. John Wiley and Sons, New York.

COE, 1984, HEC-2

Department of the Navy, 1982, Soil Mechanics Design Manual 7.1, Naval Facilities Engineering Command, Alexandria, VA, 22332, Figure Nos. 3 and 7

Giroud, J.P. 1981. Designing with Geotextiles. Paper submitted in 1984, 4th Edition of Geotextiles and Geomembranes, Definitions, Properties and Design. Industrial Fabrics Association International. St. Paul, MN

HKM Associates. November 1983. Hydrologic Potential for Hyalite Creek Watershed. Billings, Montana.

HKM Associates. April 1984a. Flood Hydrology, Middle Creek Dam. Billings, Montana.

HKM Associates. April 1984b. Geotechnical Investigation, Middle Creek Dam. Billings, Montana.

HKM Associates. February 1985. Middle (Hyalite) Creek Dam Rehabilitation Feasibility Study. Billings, Montana.

HKM Associates. December 1986. Middle Creek Dam Rehabilitation Environmental Assessment. Billings, Montana.

HKM Associates. April 1, 1987. Middle Creek Dam Rehabilitation Loan Application Report. Billings, Montana.

HKM, 1987 - Loan Application Report

Houston & DeAngelis, 1982 "A Site Specific Study of a Labyrinth"

Jansen, Robert B. 1988. Advanced Dam Engineering for Design, Construction, and Rehabilitation. Van Nostrand Reinhold, New York.

MDOH, 1982 - Surfacing Design Manual Montana Department of Highways

Rhone, T. J., December 1977 - Baffled Apron as Spillway Energy Dissipator, Journal of Hydraulic Div. ASCE

Seed, H. Bolton and Whitman, Robert V. 1970 "Design of Earth Retaining Structures for Dynamic Loads" Journal of Soil Mechanics

Wright, Stephen G., 1987. "UTEXAS2 (University of TEXas Analysis of Slopes - Version 2): A Computer Program for Slope Stability Calculations". Version 1.211. Geotechnical Engineering Software GS86-1, Geotechnical Engineering Center, Civil Engineering Department, the University of Texas at Austin.

USBR, 1987 - Design of Small Dams

USBR, 1978a - Design of Small Canal Structures

USBR, 1978b - Hydraulic Design of Stilling Basins and Energy Dissipators EM No. 25

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A-2 Specifications

B-1 PMF And Reservoir Routing
B-2 Revised Probable Maximum Flood
B-3 Freeboard Requirements

C-1 Geotechnical Test Results

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D-2 Piezometer Reading
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E-3 VSL Retained Earth Design Data

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F-4 HEC-2 Printout - Principal Spillway
F-5 Labyrinth Weir

G-1 HEC-2 Printout - Auxiliary Spillway

H-1 Roadway Alignment Design
H-2 Guardrail Warrant Analysis

APPENDICES (Continued)

I-1 Principal Spillway Bridges - Typical Section and Design Parameters
I-2 Foot Bridge Alternative Comparison

J-1 Grayling Spawning Mitigation Structure
J-2 Grayling Spawning Mitigation Structure Test Results

K-1 Elevation-Area-Capacity Table
K-2 Spillway Rating Table
K-3 Outlet Works Rating Table

APPENDIX A

APPENDIX A-1 Drawings (Separate cover)

A-2 Specifications (Separate cover)

APPENDIX B

APPENDIX B-1

PMF AND RESERVOIR ROUTING

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            FLOOD HYDROGRAPH PACKAGE HEC-1 (IBM XT 512K VERSION) -FEB 1.1985
U.S. ARMY CORPS OF ENGINEERS, THE HYDROLOGIC ENGINEERING CENTER, 609 SECOND STREET, DAVIS, CA. 95616
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THIS HEC-1 VERSION CONTAINS ALL OPTIONS EXCEPT ECONOMICS, AND THE NUMBER OF PLANS ARE REDUCED TO 3
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                              HEC-1 INPUT                                              PAGE  1

LINE          ID.......1.......2.......3.......4.......5.......6.......7.......8.......9......10

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  2           ID        PMF - Revised HMR55 Values,Final Rating Curves,IHEC1J
  3           ID        HKM Associates
  4           IT      12  1JUN90         0      275
  5           IN      30  1JUN90
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  8           PI    .027    .027    .027    .027    .027    .027    .028    .028    .028    .028
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 20           PI    .060    .060    .055    .055    .055    .055    .055    .055    .055    .055
 21           PI    .055    .055    .028    .028    .028    .028    .028    .028    .027    .027
 22           PI    .027    .027    .027    .027

 23           KK      IN Inflow To Middle Creek Reservoir
 24           PT       7
 25           PW       1
 26           PR       7
 27           PW       1
 28           BA      27
 29           BF     260   -0.25       1
 30           UC     1.5     5.0
 31           LE   0.020     0.1       1

 32           KK     OUT Middle Creek Reservoir Outflow
 33           RS       1    STOR   10310
 34           SV     126     211     675    2211    3282    4570    6044    7976   10310   10820
 35           SE    6637    6640    6650    6670    6680    6690    6700  6710.8  6721.0    6730
 36           SQ       0     430    1240    2950    5740    9480   13890   19190   24870   30550
 37           SE  6721.0  6722.0  6723.0  6724.0  6725.0 6726.00 6727.00 6728.00 6729.00  6729.9
 38           ZZ
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                          FLOOD HYDROGRAPH PACKAGE HEC-1 (IBM XT 512K VERSION) -FEB 1,1985
        U.S. ARMY CORPS OF ENGINEERS, THE HYDROLOGIC ENGINEERING CENTER, 609 SECOND STREET, DAVIS, CA. 95616
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                          Middle Creek Dam Rehabilitation - Final Design
                          PMF - Revised HMR55 Values,Final Rating Curves,IHEC1J
                          HKM Associates

  6 IO          OUTPUT CONTROL VARIABLES
                      IPRNT           1  PRINT CONTROL
                      IPLOT           0  PLOT CONTROL
                      QSCAL          0.  HYDROGRAPH PLOT SCALE

  5 IN          TIME DATA FOR INPUT TIME SERIES
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                     JXTIME           0  STARTING TIME

    IT          HYDROGRAPH TIME DATA
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                      ITIME        0000  STARTING TIME
                         NQ         275  NUMBER OF HYDROGRAPH ORDINATES
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                     NDTIME        0648  ENDING TIME

                 COMPUTATION INTERVAL     .20 HOURS
                      TOTAL TIME BASE   54.80 HOURS

           ENGLISH UNITS


*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***

            **************
            *            *
 23 KK      *      IN    *      Inflow To Middle Creek Reservoir
            *            *
            **************

              SUBBASIN RUNOFF DATA

 28 BA          SUBBASIN CHARACTERISTICS
                      TAREA       27.00  SUBBASIN AREA

 29 BF          BASE FLOW CHARACTERISTICS
                      STRTQ      260.00  INITIAL FLOW
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                ORCSN        -.25  BEGIN BASE FLOW RECESSION
                RTIOR    1.00000  RECESSION CONSTANT

            PRECIPITATION DATA

24 PT        TOTAL STORM STATIONS         7
25 FW                     WEIGHTS      1.00

26 PR          RECORDING STATIONS         7
27 FW                     WEIGHTS      1.00

31 LE       EXPONENTIAL LOSS RATE
                STRKR         .02  INITIAL VALUE OF LOSS COEFFICIENT
                DLTKR         .10  INITIAL LOSS
                RTIOL        1.00  LOSS COEFFICIENT RECESSION CONSTANT
                ERAIN         .00  EXPONENT OF PRECIPITATION
                RTIMP         .00  PERCENT IMPERVIOUS AREA

30 UC       CLARK UNITGRAPH
                   TC        1.50  TIME OF CONCENTRATION
                    R        5.00  STORAGE COEFFICIENT

            SYNTHETIC ACCUMULATED-AREA VS. TIME CURVE WILL BE USED

                                              ***

           PRECIPITATION STATION DATA

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      1789.     1718.     1651.     1586.     1524.     1464.     1407.     1352.     1299.     1248.
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        33.       31.       30.       29.       28.       27.       26.       25.       24.       23.
        22.       21.       20.       19.       19.       18.       17.

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                                            HYDROGRAPH AT STATION       IN

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                                                          *
       DA MON HRMN  ORD     RAIN     LOSS   EXCESS       COMP Q       *      DA MON HRMN  ORD     RAIN     LOSS   EXCESS       COMP Q
                                                          *
        1 JUN 0000    1      .00      .00      .00        260.        *       2 JUN 0336  139      .15      .00      .15        7505.
        1 JUN 0012    2      .01      .01      .00        260.        *       2 JUN 0348  140      .15      .00      .15        7682.
        1 JUN 0024    3      .01      .01      .00        262.        *       2 JUN 0400  141      .15      .00      .15        7865.
        1 JUN 0036    4      .01      .01      .00        265.        *       2 JUN 0412  142      .16      .00      .16        8053.
        1 JUN 0048    5      .01      .01      .00        270.        *       2 JUN 0424  143      .16      .00      .16        8246.
        1 JUN 0100    6      .01      .01      .00        277.        *       2 JUN 0436  144      .16      .00      .16        8440.
        1 JUN 0112    7      .01      .01      .01        287.        *       2 JUN 0448  145      .16      .00      .16        8633.
        1 JUN 0124    8      .01      .01      .01        299.        *       2 JUN 0500  146      .16      .00      .16        8825.
        1 JUN 0136    9      .01      .01      .01        312.        *       2 JUN 0512  147      .17      .00      .17        9017.
        1 JUN 0148   10      .01      .00      .01        326.        *       2 JUN 0524  148      .17      .00      .17        9208.
        1 JUN 0200   11      .01      .00      .01        341.        *       2 JUN 0536  149      .17      .00      .17        9399.
        1 JUN 0212   12      .01      .00      .01        356.        *       2 JUN 0548  150      .17      .00      .17        9589.
        1 JUN 0224   13      .01      .00      .01        372.        *       2 JUN 0600  151      .17      .00      .17        9778.
        1 JUN 0236   14      .01      .00      .01        387.        *       2 JUN 0612  152      .18      .00      .18        9966.
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 1 JUN 0248   15     .01     .00     .01      403.     *    2 JUN 0624  153    .18     .00     .18     10154.
 1 JUN 0300   16     .01     .00     .01      418.     *    2 JUN 0636  154    .18     .00     .18     10342.
 1 JUN 0312   17     .01     .00     .01      434.     *    2 JUN 0648  155    .18     .00     .18     10529.
 1 JUN 0324   18     .01     .00     .01      449.     *    2 JUN 0700  156    .18     .00     .18     10716.
 1 JUN 0336   19     .01     .00     .01      464.     *    2 JUN 0712  157    .18     .00     .18     10900.
 1 JUN 0348   20     .01     .00     .01      479.     *    2 JUN 0724  158    .18     .00     .18     11081.
 1 JUN 0400   21     .01     .00     .01      495.     *    2 JUN 0736  159    .18     .00     .18     11258.
 1 JUN 0412   22     .01     .00     .01      509.     *    2 JUN 0748  160    .18     .00     .18     11428.
 1 JUN 0424   23     .01     .00     .01      524.     *    2 JUN 0800  161    .18     .00     .18     11591.
 1 JUN 0436   24     .01     .00     .01      538.     *    2 JUN 0812  162    .19     .00     .19     11749.
 1 JUN 0448   25     .01     .00     .01      552.     *    2 JUN 0824  163    .19     .00     .19     11904.
 1 JUN 0500   26     .01     .00     .01      565.     *    2 JUN 0836  164    .19     .00     .19     12058.
 1 JUN 0512   27     .01     .00     .01      577.     *    2 JUN 0848  165    .19     .00     .19     12212.
 1 JUN 0524   28     .01     .00     .01      590.     *    2 JUN 0900  166    .19     .00     .19     12366.
 1 JUN 0536   29     .01     .00     .01      601.     *    2 JUN 0912  167    .22     .00     .22     12524.
 1 JUN 0548   30     .01     .00     .01      613.     *    2 JUN 0924  168    .22     .00     .22     12689.
 1 JUN 0600   31     .01     .00     .01      623.     *    2 JUN 0936  169    .22     .00     .22     12865.
 1 JUN 0612   32     .02     .00     .02      635.     *    2 JUN 0948  170    .22     .00     .22     13052.
 1 JUN 0624   33     .02     .00     .02      650.     *    2 JUN 1000  171    .22     .00     .22     13251.
 1 JUN 0636   34     .02     .00     .02      669.     *    2 JUN 1012  172    .24     .00     .24     13461.
 1 JUN 0648   35     .02     .00     .02      694.     *    2 JUN 1024  173    .24     .00     .24     13682.
 1 JUN 0700   36     .02     .00     .02      726.     *    2 JUN 1036  174    .24     .00     .24     13911.
 1 JUN 0712   37     .02     .00     .02      761.     *    2 JUN 1048  175    .24     .00     .24     14144.
 1 JUN 0724   38     .02     .00     .02      801.     *    2 JUN 1100  176    .24     .00     .24     14381.
 1 JUN 0736   39     .02     .00     .02      840.     *    2 JUN 1112  177    .35     .00     .35     14633.
 1 JUN 0748   40     .02     .00     .02      879.     *    2 JUN 1124  178    .35     .00     .35     14922.
 1 JUN 0800   41     .02     .00     .02      916.     *    2 JUN 1136  179    .56     .00     .56     15284.
 1 JUN 0812   42     .02     .00     .02      952.     *    2 JUN 1148  180    .77     .00     .77     15796.
 1 JUN 0824   43     .02     .00     .02      986.     *    2 JUN 1200  181    .77     .00     .77     16533.
 1 JUN 0836   44     .02     .00     .02     1019.     *    2 JUN 1212  182   1.40     .00    1.40     17608.
 1 JUN 0848   45     .02     .00     .02     1051.     *    2 JUN 1224  183   1.40     .00    1.40     19156.
 1 JUN 0900   46     .02     .00     .02     1082.     *    2 JUN 1236  184    .88     .00     .87     21164.
 1 JUN 0912   47     .02     .00     .02     1111.     *    2 JUN 1248  185    .35     .00     .35     23448.
 1 JUN 0924   48     .02     .00     .02     1139.     *    2 JUN 1300  186    .35     .00     .35     25740.
 1 JUN 0936   49     .02     .00     .02     1166.     *    2 JUN 1312  187    .24     .00     .24     27757.
 1 JUN 0948   50     .02     .00     .02     1192.     *    2 JUN 1324  188    .24     .00     .24     29283.
 1 JUN 1000   51     .02     .00     .02     1217.     *    2 JUN 1336  189    .24     .00     .24     30209.
 1 JUN 1012   52     .02     .00     .02     1241.     *    2 JUN 1348  190    .24     .00     .24     30544.
 1 JUN 1024   53     .02     .00     .02     1264.     *    2 JUN 1400  191    .24     .00     .24     30460.
 1 JUN 1036   54     .02     .00     .02     1286.     *    2 JUN 1412  192    .22     .00     .22     30179.
 1 JUN 1048   55     .02     .00     .02     1307.     *    2 JUN 1424  193    .22     .00     .22     29832.
 1 JUN 1100   56     .02     .00     .02     1328.     *    2 JUN 1436  194    .22     .00     .22     29464.
 1 JUN 1112   57     .02     .00     .02     1348.     *    2 JUN 1448  195    .22     .00     .22     29094.
 1 JUN 1124   58     .02     .00     .02     1367.     *    2 JUN 1500  196    .22     .00     .22     28725.
 1 JUN 1136   59     .02     .00     .02     1387.     *    2 JUN 1512  197    .19     .00     .19     28357.
 1 JUN 1148   60     .02     .00     .02     1408.     *    2 JUN 1524  198    .19     .00     .19     27984.
 1 JUN 1200   61     .02     .00     .02     1429.     *    2 JUN 1536  199    .19     .00     .19     27607.
 1 JUN 1212   62     .02     .00     .02     1450.     *    2 JUN 1548  200    .19     .00     .19     27226.
 1 JUN 1224   63     .02     .00     .02     1471.     *    2 JUN 1600  201    .19     .00     .19     26840.
 1 JUN 1236   64     .02     .00     .02     1492.     *    2 JUN 1612  202    .18     .00     .18     26452.
 1 JUN 1248   65     .02     .00     .02     1512.     *    2 JUN 1624  203    .18     .00     .18     26064.
 1 JUN 1300   66     .02     .00     .02     1531.     *    2 JUN 1636  204    .18     .00     .18     25679.
 1 JUN 1312   67     .02     .00     .02     1549.     *    2 JUN 1648  205    .18     .00     .18     25301.
 1 JUN 1324   68     .02     .00     .02      1567.       *     2 JUN 1700  206    .18     .00     .18     24933.
 1 JUN 1336   69     .03     .00     .03      1585.       *     2 JUN 1712  207    .18     .00     .18     24573.
 1 JUN 1348   70     .04     .00     .04      1606.       *     2 JUN 1724  208    .18     .00     .18     24222.
 1 JUN 1400   71     .04     .00     .04      1633.       *     2 JUN 1736  209    .18     .00     .18     23884.
 1 JUN 1412   72     .04     .00     .04      1667.       *     2 JUN 1748  210    .18     .00     .18     23558.
 1 JUN 1424   73     .04     .00     .04      1710.       *     2 JUN 1800  211    .18     .00     .18     23245.
 1 JUN 1436   74     .04     .00     .04      1761.       *     2 JUN 1812  212    .17     .00     .17     22943.
 1 JUN 1448   75     .04     .00     .04      1818.       *     2 JUN 1824  213    .17     .00     .17     22650.
 1 JUN 1500   76     .04     .00     .04      1877.       *     2 JUN 1836  214    .17     .00     .17     22363.
 1 JUN 1512   77     .04     .00     .04      1936.       *     2 JUN 1848  215    .17     .00     .17     22082.
 1 JUN 1524   78     .04     .00     .04      1994.       *     2 JUN 1900  216    .17     .00     .17     21805.
 1 JUN 1536   79     .04     .00     .04      2049.       *     2 JUN 1912  217    .16     .00     .16     21532.
 1 JUN 1548   80     .04     .00     .04      2101.       *     2 JUN 1924  218    .16     .00     .16     21262.
 1 JUN 1600   81     .04     .00     .04      2152.       *     2 JUN 1936  219    .16     .00     .16     20996.
 1 JUN 1612   82     .04     .00     .04      2202.       *     2 JUN 1948  220    .16     .00     .16     20734.
 1 JUN 1624   83     .04     .00     .04      2250.       *     2 JUN 2000  221    .16     .00     .16     20476.
 1 JUN 1636   84     .04     .00     .04      2299.       *     2 JUN 2012  222    .15     .00     .15     20221.
 1 JUN 1648   85     .04     .00     .04      2348.       *     2 JUN 2024  223    .15     .00     .15     19969.
 1 JUN 1700   86     .04     .00     .04      2398.       *     2 JUN 2036  224    .15     .00     .15     19719.
 1 JUN 1712   87     .04     .00     .04      2448.       *     2 JUN 2048  225    .15     .00     .15     19473.
 1 JUN 1724   88     .04     .00     .04      2498.       *     2 JUN 2100  226    .15     .00     .15     19230.
 1 JUN 1736   89     .04     .00     .04      2547.       *     2 JUN 2112  227    .13     .00     .13     18988.
 1 JUN 1748   90     .04     .00     .04      2594.       *     2 JUN 2124  228    .13     .00     .13     18746.
 1 JUN 1800   91     .04     .00     .04      2639.       *     2 JUN 2136  229    .13     .00     .13     18500.
 1 JUN 1812   92     .04     .00     .04      2682.       *     2 JUN 2148  230    .13     .00     .13     18252.
 1 JUN 1824   93     .04     .00     .04      2724.       *     2 JUN 2200  231    .13     .00     .13     18001.
 1 JUN 1836   94     .05     .00     .05      2765.       *     2 JUN 2212  232    .13     .00     .13     17749.
 1 JUN 1848   95     .06     .00     .05      2806.       *     2 JUN 2224  233    .13     .00     .13     17498.
 1 JUN 1900   96     .06     .00     .05      2852.       *     2 JUN 2236  234    .13     .00     .13     17252.
 1 JUN 1912   97     .06     .00     .05      2902.       *     2 JUN 2248  235    .13     .00     .13     17015.
 1 JUN 1924   98     .06     .00     .05      2957.       *     2 JUN 2300  236    .13     .00     .13     16788.
 1 JUN 1936   99     .06     .00     .05      3017.       *     2 JUN 2312  237    .11     .00     .11     16567.
 1 JUN 1948  100     .06     .00     .05      3081.       *     2 JUN 2324  238    .11     .00     .11     16349.
 1 JUN 2000  101     .06     .00     .05      3147.       *     2 JUN 2336  239    .11     .00     .11     16131.
 1 JUN 2012  102     .06     .00     .05      3211.       *     2 JUN 2348  240    .11     .00     .11     15910.
 1 JUN 2024  103     .06     .00     .05      3273.       *     3 JUN 0000  241    .11     .00     .11     15687.
 1 JUN 2036  104     .06     .00     .05      3332.       *     3 JUN 0012  242    .08     .00     .07     15458.
 1 JUN 2048  105     .06     .00     .05      3389.       *     3 JUN 0024  243    .08     .00     .07     15220.
 1 JUN 2100  106     .06     .00     .05      3444.       *     3 JUN 0036  244    .08     .00     .07     14969.
 1 JUN 2112  107     .07     .00     .07      3499.       *     3 JUN 0048  245    .08     .00     .07     14708.
 1 JUN 2124  108     .07     .00     .07      3558.       *     3 JUN 0100  246    .08     .00     .07     14435.
 1 JUN 2136  109     .07     .00     .07      3624.       *     3 JUN 0112  247    .08     .00     .07     14153.
 1 JUN 2148  110     .07     .00     .07      3699.       *     3 JUN 0124  248    .08     .00     .07     13868.
 1 JUN 2200  111     .07     .00     .07      3783.       *     3 JUN 0136  249    .08     .00     .07     13584.
 1 JUN 2212  112     .08     .00     .07      3874.       *     3 JUN 0148  250    .08     .00     .07     13309.
 1 JUN 2224  113     .08     .00     .07      3970.       *     3 JUN 0200  251    .08     .00     .07     13043.
 1 JUN 2236  114     .08     .00     .07      4066.       *     3 JUN 0212  252    .07     .00     .07     12786.
 1 JUN 2248  115     .08     .00     .07      4159.       *     3 JUN 0224  253    .07     .00     .07     12537.
 1 JUN 2300  116     .08     .00     .07      4249.       *     3 JUN 0236  254    .07     .00     .07     12297.
 1 JUN 2312  117     .08     .00     .07      4336.       *     3 JUN 0248  255    .07     .00     .07     12067.
 1 JUN 2324  118     .08     .00     .07      4420.       *     3 JUN 0300  256    .07     .00     .07     11845.
 1 JUN 2336  119     .08     .00     .07      4503.       *     3 JUN 0312  257    .06     .00     .05     11629.
 1 JUN 2348  120     .08     .00     .07      4584.       *     3 JUN 0324  258    .06     .00     .05     11416.
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  2 JUN 0000  121    .08     .00     .07      4664.       *      3 JUN 0336  259    .06     .00     .05     11201.
  2 JUN 0012  122    .11     .00     .11      4746.       *      3 JUN 0348  260    .06     .00     .05     10983.
  2 JUN 0024  123    .11     .00     .11      4838.       *      3 JUN 0400  261    .06     .00     .05     10761.
  2 JUN 0036  124    .11     .00     .11      4943.       *      3 JUN 0412  262    .06     .00     .05     10538.
  2 JUN 0048  125    .11     .00     .11      5065.       *      3 JUN 0424  263    .06     .00     .05     10316.
  2 JUN 0100  126    .11     .00     .11      5203.       *      3 JUN 0436  264    .06     .00     .05     10098.
  2 JUN 0112  127    .13     .00     .13      5357.       *      3 JUN 0448  265    .06     .00     .05      9887.
  2 JUN 0124  128    .13     .00     .13      5526.       *      3 JUN 0500  266    .06     .00     .05      9685.
  2 JUN 0136  129    .13     .00     .13      5704.       *      3 JUN 0512  267    .06     .00     .05      9491.
  2 JUN 0148  130    .13     .00     .13      5887.       *      3 JUN 0524  268    .06     .00     .05      9305.
  2 JUN 0200  131    .13     .00     .13      6075.       *      3 JUN 0536  269    .05     .00     .05      9125.
  2 JUN 0212  132    .13     .00     .13      6265.       *      3 JUN 0548  270    .04     .00     .04      8950.
  2 JUN 0224  133    .13     .00     .13      6455.       *      3 JUN 0600  271    .04     .00     .04      8776.
  2 JUN 0236  134    .13     .00     .13      6642.       *      3 JUN 0612  272    .04     .00     .04      8603.
  2 JUN 0248  135    .13     .00     .13      6822.       *      3 JUN 0624  273    .04     .00     .04      8429.
  2 JUN 0300  136    .13     .00     .13      6995.       *      3 JUN 0636  274    .04     .00     .04      8254.
  2 JUN 0312  137    .15     .00     .15      7164.       *      3 JUN 0648  275    .04     .00     .04      8080.
  2 JUN 0324  138    .15     .00     .15      7333.       *
                                                          *
************************************************************************************************************************************

    TOTAL RAINFALL =    32.02, TOTAL LOSS =     1.12, TOTAL EXCESS =    30.90

 PEAK FLOW      TIME                              MAXIMUM AVERAGE FLOW
   (CFS)        (HR)                     6-HR         24-HR        72-HR       54.80-HR
   30544.      37.80        (CFS)       26600.        17510.        9314.         9314.
                          (INCHES)       9.160        24.118       29.293        29.293
                           (AC-FT)      13190.        34730.       42181.        42181.

                            CUMULATIVE AREA =    27.00 SQ MI



*** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** *** ***


             **************
             *            *
  32 KK      *    OUT     *      Middle Creek Reservoir Outflow
             *            *
             **************

                HYDROGRAPH ROUTING DATA

  33 RS           STORAGE ROUTING
                        NSTPS             1   NUMBER OF SUBREACHES
                         ITYP          STOR   TYPE OF INITIAL CONDITION
                       RSVRIC      10310.00   INITIAL CONDITION
                            X           .00  WORKING R AND D COEFFICIENT

  34 SV             STORAGE       126.0       211.0       675.0      2211.0      3282.0      4570.0      6044.0      7976.0     10310.0     10820.0
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35 SE         ELEVATION     6637.00   6640.00   6650.00   6670.00   6680.00   6690.00   6700.00   6710.80   6721.00   6730.00

36 SQ         DISCHARGE          0.      430.     1240.     2950.     5740.     9480.    13890.    19190.    24870.    30550.

37 SE         ELEVATION     6721.00   6722.00   6723.00   6724.00   6725.00   6726.00   6727.00   6728.00   6729.00   6729.90

                                                       ***

                                      COMPUTED STORAGE-OUTFLOW-ELEVATION DATA

              STORAGE     126.00    211.00    675.00   2211.00   3282.00   4570.00   6044.00   7976.00  10310.00  10366.67
              OUTFLOW        .00       .00       .00       .00       .00       .00       .00       .00       .00    430.00
            ELEVATION    6637.00   6640.00   6650.00   6670.00   6680.00   6690.00   6700.00   6710.80   6721.00   6722.00

              STORAGE   10423.33  10480.00  10536.67  10593.33  10650.00  10706.67  10763.33  10814.33  10820.00
              OUTFLOW    1240.00   2950.00   5740.00   9480.00  13890.00  19190.00  24870.00  30550.00  31181.80
            ELEVATION    6723.00   6724.00   6725.00   6726.00   6727.00   6728.00   6729.00   6729.90   6730.00

*********************************************************************************************************************

                                          HYDROGRAPH AT STATION      OUT

*********************************************************************************************************************
                                               *                                               *
 DA MON HRMN ORD   OUTFLOW  STORAGE     STAGE  * DA MON HRMN ORD   OUTFLOW  STORAGE     STAGE  * DA MON HRMN ORD   OUTFLOW  STORAGE     STAGE
                                               *                                               *
  1 JUN 0000   1        0.  10310.0    6721.0  *  1 JUN 1824  93     2635.  10469.6    6723.8  *  2 JUN 1248 185    22084.  10735.5    6728.5
  1 JUN 0012   2       31.  10314.0    6721.1  *  1 JUN 1836  94     2679.  10471.0    6723.8  *  2 JUN 1300 186    24359.  10758.2    6728.9
  1 JUN 0024   3       58.  10317.6    6721.1  *  1 JUN 1848  95     2721.  10472.4    6723.9  *  2 JUN 1312 187    26620.  10779.0    6729.3
  1 JUN 0036   4       82.  10320.8    6721.2  *  1 JUN 1900  96     2764.  10473.8    6723.9  *  2 JUN 1324 188    28441.  10795.4    6729.6
  1 JUN 0048   5      104.  10323.7    6721.2  *  1 JUN 1912  97     2809.  10475.3    6723.9  *  2 JUN 1336 189    29692.  10806.6    6729.8
  1 JUN 0100   6      124.  10326.3    6721.3  *  1 JUN 1924  98     2857.  10476.9    6723.9  *  2 JUN 1348 190    30348.  10812.5    6729.9
  1 JUN 0112   7      143.  10328.8    6721.3  *  1 JUN 1936  99     2909.  10478.6    6724.0  *  2 JUN 1400 191    30496.  10813.8    6729.9
  1 JUN 0124   8      160.  10331.1    6721.4  *  1 JUN 1948 100     2972.  10480.4    6724.0  *  2 JUN 1412 192    30327.  10812.3    6729.9
  1 JUN 0136   9      177.  10333.4    6721.4  *  1 JUN 2000 101     3054.  10482.1    6724.0  *  2 JUN 1424 193    30018.  10809.6    6729.8
  1 JUN 0148  10      194.  10335.6    6721.5  *  1 JUN 2012 102     3126.  10483.6    6724.1  *  2 JUN 1436 194    29663.  10806.4    6729.8
  1 JUN 0200  11      211.  10337.8    6721.5  *  1 JUN 2024 103     3193.  10484.9    6724.1  *  2 JUN 1448 195    29295.  10803.1    6729.7
  1 JUN 0212. 12      227.  10339.9    6721.5  *  1 JUN 2036 104     3256.  10486.2    6724.1  *  2 JUN 1500 196    28925.  10799.7    6729.6
  1 JUN 0224  13      243.  10342.0    6721.6  *  1 JUN 2048 105     3317.  10487.4    6724.1  *  2 JUN 1512 197    28557.  10796.4    6729.6
  1 JUN 0236  14      259.  10344.2    6721.6  *  1 JUN 2100 106     3375.  10488.6    6724.2  *  2 JUN 1524 198    28186.  10793.1    6729.5
  1 JUN 0248  15      275.  10346.3    6721.6  *  1 JUN 2112 107     3431.  10489.8    6724.2  *  2 JUN 1536 199    27812.  10789.7    6729.5
  1 JUN 0300  16      291.  10348.4    6721.7  *  1 JUN 2124 108     3488.  10490.9    6724.2  *  2 JUN 1548 200    27433.  10786.3    6729.4
  1 JUN 0312  17      307.  10350.5    6721.7  *  1 JUN 2136 109     3548.  10492.1    6724.2  *  2 JUN 1600 201    27050.  10782.9    6729.3
  1 JUN 0324  18      323.  10352.6    6721.8  *  1 JUN 2148 110     3614.  10493.5    6724.2  *  2 JUN 1612 202    26663.  10779.4    6729.3
  1 JUN 0336  19      339.  10354.6    6721.8  *  1 JUN 2200 111     3687.  10495.0    6724.3  *  2 JUN 1624 203    26275.  10775.9    6729.2
  1 JUN 0348  20      354.  10356.7    6721.8  *  1 JUN 2212 112     3769.  10496.6    6724.3  *  2 JUN 1636 204    25888.  10772.5    6729.2
  1 JUN 0400  21      370.  10358.8    6721.9  *  1 JUN 2224 113     3857.  10498.4    6724.3  *  2 JUN 1648 205    25506.  10769.0    6729.1
  1 JUN 0412  22      386.  10360.8    6721.9  *  1 JUN 2236 114     3950.  10500.3    6724.4  *  2 JUN 1700 206    25133.  10765.7    6729.0
  1 JUN 0424  23      401.  10362.9    6721.9  *  1 JUN 2248 115     4044.  10502.2    6724.4  *  2 JUN 1712 207    24774.  10762.4    6729.0
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1 JUN 0436  24     416.  10364.9  6722.0 *  1 JUN 2300 116    4136.  10504.1  6724.4 *  2 JUN 1724 208   24433.  10759.0  6728.9
1 JUN 0448  25     433.  10366.9  6722.0 *  1 JUN 2312 117    4226.  10505.9  6724.5 *  2 JUN 1736 209   24089.  10755.5  6728.9
1 JUN 0500  26     459.  10368.7  6722.0 *  1 JUN 2324 118    4314.  10507.7  6724.5 *  2 JUN 1748 210   23755.  10752.2  6728.8
1 JUN 0512  27     483.  10370.4  6722.1 *  1 JUN 2336 119    4399.  10509.4  6724.5 *  2 JUN 1800 211   23435.  10749.0  6728.7
1 JUN 0524  28     504.  10371.9  6722.1 *  1 JUN 2348 120    4483.  10511.1  6724.5 *  2 JUN 1812 212   23126.  10745.9  6728.7
1 JUN 0536  29     524.  10373.2  6722.1 *  2 JUN 0000 121    4564.  10512.8  6724.6 *  2 JUN 1824 213   22828.  10743.0  6728.6
1 JUN 0548  30     541.  10374.4  6722.1 *  2 JUN 0012 122    4646.  10514.4  6724.6 *  2 JUN 1836 214   22537.  10740.1  6728.6
1 JUN 0600  31     557.  10375.6  6722.2 *  2 JUN 0024 123    4730.  10516.2  6724.6 *  2 JUN 1848 215   22252.  10737.2  6728.5
1 JUN 0612  32     573.  10376.6  6722.2 *  2 JUN 0036 124    4823.  10518.0  6724.7 *  2 JUN 1900 216   21972.  10734.4  6728.5
1 JUN 0624  33     587.  10377.7  6722.2 *  2 JUN 0048 125    4927.  10520.2  6724.7 *  2 JUN 1912 217   21697.  10731.7  6728.4
1 JUN 0636  34     603.  10378.7  6722.2 *  2 JUN 0100 126    5047.  10522.6  6724.8 *  2 JUN 1924 218   21425.  10729.0  6728.4
1 JUN 0648  35     619.  10379.9  6722.2 *  2 JUN 0112 127    5182.  10525.3  6724.8 *  2 JUN 1936 219   21157.  10726.3  6728.3
1 JUN 0700  36     638.  10381.3  6722.3 *  2 JUN 0124 128    5332.  10528.4  6724.9 *  2 JUN 1948 220   20893.  10723.7  6728.3
1 JUN 0712  37     661.  10382.8  6722.3 *  2 JUN 0136 129    5496.  10531.7  6724.9 *  2 JUN 2000 221   20632.  10721.1  6728.3
1 JUN 0724  38     686.  10384.6  6722.3 *  2 JUN 0148 130    5669.  10535.2  6725.0 *  2 JUN 2012 222   20375.  10718.5  6728.2
1 JUN 0736  39     714.  10386.6  6722.4 *  2 JUN 0200 131    5874.  10538.7  6725.0 *  2 JUN 2024 223   20121.  10716.0  6728.2
1 JUN 0748  40     745.  10388.7  6722.4 *  2 JUN 0212 132    6083.  10541.9  6725.1 *  2 JUN 2036 224   19870.  10713.4  6728.1
1 JUN 0800  41     777.  10391.0  6722.4 *  2 JUN 0224 133    6279.  10544.8  6725.1 *  2 JUN 2048 225   19622.  10711.0  6728.1
1 JUN 0812  42     811.  10393.3  6722.5 *  2 JUN 0236 134    6469.  10547.7  6725.2 *  2 JUN 2100 226   19377.  10708.5  6728.0
1 JUN 0824  43     844.  10395.6  6722.5 *  2 JUN 0248 135    6655.  10550.5  6725.2 *  2 JUN 2112 227   19136.  10706.1  6728.0
1 JUN 0836  44     878.  10398.0  6722.6 *  2 JUN 0300 136    6834.  10553.2  6725.3 *  2 JUN 2124 228   18902.  10703.6  6727.9
1 JUN 0848  45     911.  10400.3  6722.6 *  2 JUN 0312 137    7008.  10555.9  6725.3 *  2 JUN 2136 229   18659.  10701.0  6727.9
1 JUN 0900  46     944.  10402.6  6722.6 *  2 JUN 0324 138    7178.  10558.4  6725.4 *  2 JUN 2148 230   18412.  10698.4  6727.9
1 JUN 0912  47     976.  10404.9  6722.7 *  2 JUN 0336 139    7348.  10561.0  6725.4 *  2 JUN 2200 231   18163.  10695.7  6727.8
1 JUN 0924  48    1007.  10407.1  6722.7 *  2 JUN 0348 140    7521.  10563.7  6725.5 *  2 JUN 2212 232   17912.  10693.0  6727.8
1 JUN 0936  49    1038.  10409.2  6722.8 *  2 JUN 0400 141    7699.  10566.4  6725.5 *  2 JUN 2224 233   17660.  10690.3  6727.7
1 JUN 0948  50    1068.  10411.3  6722.8 *  2 JUN 0412 142    7883.  10569.1  6725.6 *  2 JUN 2236 234   17411.  10687.6  6727.7
1 JUN 1000  51    1097.  10413.3  6722.8 *  2 JUN 0424 143    8071.  10572.0  6725.6 *  2 JUN 2248 235   17169.  10685.1  6727.6
1 JUN 1012  52    1125.  10415.3  6722.9 *  2 JUN 0436 144    8263.  10574.9  6725.7 *  2 JUN 2300 236   16936.  10682.6  6727.6
1 JUN 1024  53    1152.  10417.2  6722.9 *  2 JUN 0448 145    8456.  10577.8  6725.7 *  2 JUN 2312 237   16711.  10680.2  6727.5
1 JUN 1036  54    1178.  10419.0  6722.9 *  2 JUN 0500 146    8649.  10580.7  6725.8 *  2 JUN 2324 238   16491.  10677.8  6727.5
1 JUN 1048  55    1203.  10420.7  6723.0 *  2 JUN 0512 147    8841.  10583.7  6725.8 *  2 JUN 2336 239   16272.  10675.5  6727.4
1 JUN 1100  56    1227.  10422.4  6723.0 *  2 JUN 0524 148    9033.  10586.6  6725.9 *  2 JUN 2348 240   16053.  10673.1  6727.4
1 JUN 1112  57    1260.  10424.0  6723.0 *  2 JUN 0536 149    9224.  10589.5  6725.9 *  3 JUN 0000 241   15831.  10670.8  6727.4
1 JUN 1124  58    1299.  10425.3  6723.0 *  2 JUN 0548 150    9415.  10592.3  6726.0 *  3 JUN 0012 242   15606.  10668.3  6727.3
1 JUN 1136  59    1330.  10426.3  6723.1 *  2 JUN 0600 151    9618.  10595.1  6726.0 *  3 JUN 0024 243   15373.  10665.9  6727.3
1 JUN 1148  60    1357.  10427.2  6723.1 *  2 JUN 0612 152    9817.  10597.7  6726.1 *  3 JUN 0036 244   15130.  10663.3  6727.2
1 JUN 1200  61    1381.  10428.0  6723.1 *  2 JUN 0624 153   10007.  10600.1  6726.1 *  3 JUN 0048 245   14876.  10660.5  6727.2
1 JUN 1212  62    1404.  10428.8  6723.1 *  2 JUN 0636 154   10196.  10602.5  6726.2 *  3 JUN 0100 246   14610.  10657.7  6727.1
1 JUN 1224  63    1427.  10429.5  6723.1 *  2 JUN 0648 155   10384.  10604.9  6726.2 *  3 JUN 0112 247   14335.  10654.8  6727.1
1 JUN 1236  64    1449.  10430.2  6723.1 *  2 JUN 0700 156   10571.  10607.3  6726.2 *  3 JUN 0124 248   14052.  10651.7  6727.0
1 JUN 1248  65    1470.  10430.9  6723.1 *  2 JUN 0712 157   10756.  10609.7  6726.3 *  3 JUN 0136 249   13780.  10648.6  6727.0
1 JUN 1300  66    1490.  10431.6  6723.1 *  2 JUN 0724 158   10940.  10612.1  6726.3 *  3 JUN 0148 250   13519.  10645.2  6726.9
1 JUN 1312  67    1510.  10432.3  6723.2 *  2 JUN 0736 159   11120.  10614.4  6726.4 *  3 JUN 0200 251   13251.  10641.8  6726.9
1 JUN 1324  68    1529.  10432.9  6723.2 *  2 JUN 0748 160   11294.  10616.6  6726.4 *  3 JUN 0212 252   12987.  10638.4  6726.8
1 JUN 1336  69    1548.  10433.5  6723.2 *  2 JUN 0800 161   11463.  10618.8  6726.4 *  3 JUN 0224 253   12732.  10635.1  6726.7
1 JUN 1348  70    1567.  10434.2  6723.2 *  2 JUN 0812 162   11625.  10620.9  6726.5 *  3 JUN 0236 254   12486.  10632.0  6726.7
1 JUN 1400  71    1588.  10434.9  6723.2 *  2 JUN 0824 163   11783.  10622.9  6726.5 *  3 JUN 0248 255   12248.  10628.9  6726.6
1 JUN 1412  72    1613.  10435.7  6723.2 *  2 JUN 0836 164   11938.  10624.9  6726.6 *  3 JUN 0300 256   12019.  10626.0  6726.6
1 JUN 1424  73    1643.  10436.7  6723.2 *  2 JUN 0848 165   12092.  10626.9  6726.6 *  3 JUN 0312 257   11798.  10623.1  6726.5
1 JUN 1436  74    1680.  10437.9  6723.3 *  2 JUN 0900 166   12246.  10628.9  6726.6 *  3 JUN 0324 258   11582.  10620.3  6726.5
1 JUN 1448  75    1724.  10439.4  6723.3 *  2 JUN 0912 167   12402.  10630.9  6726.7 *  3 JUN 0336 259   11368.  10617.6  6726.4
1 JUN 1500  76    1773.  10441.0  6723.3 *  2 JUN 0924 168   12562.  10632.9  6726.7 *  3 JUN 0348 260   11152.  10614.8  6726.4
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 1 JUN 1512  77     1826.  10442.8  6723.3 *  2 JUN 0936 169   12730.  10635.1  6726.7 *  3 JUN 0400 261   10933.  10612.0  6726.3
 1 JUN 1524  78     1882.  10444.6  6723.4 *  2 JUN 0948 170   12909.  10637.4  6726.8 *  3 JUN 0412 262   10711.  10609.2  6726.3
 1 JUN 1536  79     1937.  10446.4  6723.4 *  2 JUN 1000 171   13099.  10639.8  6726.8 *  3 JUN 0424 263   10489.  10606.3  6726.2
 1 JUN 1548  80     1992.  10448.3  6723.4 *  2 JUN 1012 172   13300.  10642.4  6726.9 *  3 JUN 0436 264   10268.  10603.5  6726.2
 1 JUN 1600  81     2046.  10450.0  6723.5 *  2 JUN 1024 173   13513.  10645.2  6726.9 *  3 JUN 0448 265   10052.  10600.7  6726.1
 1 JUN 1612  82     2098.  10451.8  6723.5 *  2 JUN 1036 174   13735.  10648.0  6727.0 *  3 JUN 0500 266    9844.  10598.0  6726.1
 1 JUN 1624  83     2149.  10453.5  6723.5 *  2 JUN 1048 175   13973.  10650.9  6727.0 *  3 JUN 0512 267    9644.  10595.4  6726.0
 1 JUN 1636  84     2199.  10455.1  6723.6 *  2 JUN 1100 176   14226.  10653.6  6727.1 *  3 JUN 0524 268    9454.  10592.9  6726.0
 1 JUN 1648  85     2249.  10456.8  6723.6 *  2 JUN 1112 177   14471.  10656.2  6727.1 *  3 JUN 0536 269    9285.  10590.4  6725.9
 1 JUN 1700  86     2298.  10458.4  6723.6 *  2 JUN 1124 178   14738.  10659.1  6727.2 *  3 JUN 0548 270    9110.  10587.7  6725.9
 1 JUN 1712  87     2348.  10460.1  6723.6 *  2 JUN 1136 179   15056.  10662.5  6727.2 *  3 JUN 0600 271    8936.  10585.1  6725.9
 1 JUN 1724  88     2398.  10461.7  6723.7 *  2 JUN 1148 180   15478.  10667.0  6727.3 *  3 JUN 0612 272    8762.  10582.5  6725.8
 1 JUN 1736  89     2448.  10463.4  6723.7 *  2 JUN 1200 181   16077.  10673.4  6727.4 *  3 JUN 0624 273    8588.  10579.8  6725.8
 1 JUN 1748  90     2496.  10465.0  6723.7 *  2 JUN 1212 182   16943.  10682.6  6727.6 *  3 JUN 0636 274    8414.  10577.2  6725.7
 1 JUN 1800  91     2544.  10466.6  6723.8 *  2 JUN 1224 183   18198.  10696.1  6727.8 *  3 JUN 0648 275    8240.  10574.5  6725.7
 1 JUN 1812  92     2591.  10468.1  6723.8 *  2 JUN 1236 184   19937.  10714.1  6728.1 *
                                           *                                            *
***************************************************************************************************************************************

  PEAK FLOW      TIME                                  MAXIMUM AVERAGE FLOW
    (CFS)        (HR)                        6-HR          24-HR        72-HR      54.80-HR
   30496.       38.00          (CFS)        26594.        17508.        9255.        9255.
                             (INCHES)        9.158        24.116       29.109       29.109
                              (AC-FT)       13187.        34728.       41917.       41917.

 PEAK STORAGE    TIME                                MAXIMUM AVERAGE STORAGE
   (AC-FT)       (HR)                        6-HR          24-HR        72-HR      54.80-HR
    10814.      38.00                       10778.        10685.       10553.       10553.

  PEAK STAGE     TIME                                  MAXIMUM AVERAGE STAGE
   (FEET)        (HR)                        6-HR          24-HR        72-HR      54.80-HR
   6729.89      38.00                      6729.27       6727.61      6725.29      6725.29

                             CUMULATIVE AREA =    27.00 SQ MI
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                                          RUNOFF SUMMARY
                                    FLOW IN CUBIC FEET PER SECOND
                                 TIME IN HOURS,  AREA IN SQUARE MILES

                                  PEAK   TIME OF     AVERAGE FLOW FOR MAXIMUM PERIOD      BASIN     MAXIMUM     TIME OF
       OPERATION       STATION    FLOW     PEAK       6-HOUR      24-HOUR     72-HOUR      AREA       STAGE     MAX STAGE

       HYDROGRAPH AT        IN   30544.   37.80       26600.       17510.       9314.     27.00

       ROUTED TO           OUT   30496.   38.00       26594.       17508.       9255.     27.00     6729.89        38.00


*** NORMAL END OF HEC-1 ***
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APPENDIX B-2
REVISED PROBABLE MAXIMUM FLOOD

APPENDIX B-2

REVISED PROBABLE MAXIMUM FLOOD

The probable maximum flood (PMF) for Middle Creek Dam was estimated by HKM and reported 4 years ago (HKM, April 1984). Since this time additional information has become available which requires that the PMF be re-estimated. New information includes the following:

(1) Revised HMR-55 probable maximum precipitation (PMP) values;
(2) A new USGS publication for estimating the magnitude of floods in Montana (Omang, May 1986);
(3) Release of a new version of Design of Small Dams (USBR, 1987)

The revised version of HMR-55 has not been released, however, the National Weather Service in Washington, D.C. provided provisional values for use in this design (Elwell, 1987):

Duration, hr.	Original HMR 55 PMP, in.	Provisional Revised HMR 55 PMP, in.
1	6.26	5.43
6	12.18	11.40

The PMF was re-estimated in several ways. The first approach was to use the same model used in the 1984 report, except for use of the provisional revised PMP values. Using this technique, the PMF decreased from 32,400 cfs to 30,500 cfs.

The next approach was to apply the techniques reported in the new version of Design of Small Dams (USBR, 1987). Using this technique, most parameters can be solved for directly. The Kn value, which approximates Manning's "n", is not as easy to determine. Design of Small Dams indicates that the range of Kn for the Rocky Mountain area is approximately 0.13 up to 0.26, however, due to limited data Kn should not exceed 0.16 for estimating the PMF. Using a Kn value of 0.16, the PMF peak is estimated to be about 27,500 cfs.

Both the Clark Unit Hydrograph (UHG) method used in 1984, with parameters directed by the USBR, and the 1987 Design of Small Dams techniques appear to yield unreasonably high PMF peaks when compared to a plot of PMF estimates for other projects in the region. PMF estimates for 17 projects in the area were collected and analyzed. Seven of the 17 were prepared by the USBR. The remaining 10 were prepared by consultants and at least 1 of these was reviewed and approved by the USBR. The results of this analysis are presented in Table 1 and Figure 1. The table and figure indicate the PMF for a 27 square mile (sm) drainage would be approximately 19,200 cfs.

No model can be considered reliable without some attempt at calibration. In conversations with the USBR, it was agreed that the Rocky Mountain dimensionless unit hydrograph can not be expected to be appropriate for all drainages in the Rocky Mountain region and that other unit hydrographs can be used if calibrated for the Hyalite Creek basin (Elwell, 1988a). During the 1984 study, attempts were made to calibrate against limited data at the project site having relatively low discharge peaks. In such cases where stream flow and precipitation records at the site are limited, the COE indicates it can be assumed that the frequency of a given flood is the same as the frequency of the storm producing the flood. Total storm rainfall from regional studies can be input in a hydrologic model (such as HEC-1) to determine the runoff for a given frequency. Model parameters can then be adjusted until the desired peak discharge is computed (COE, April 1982). This technique has been used by the USGS for streams similar to

TABLE 1

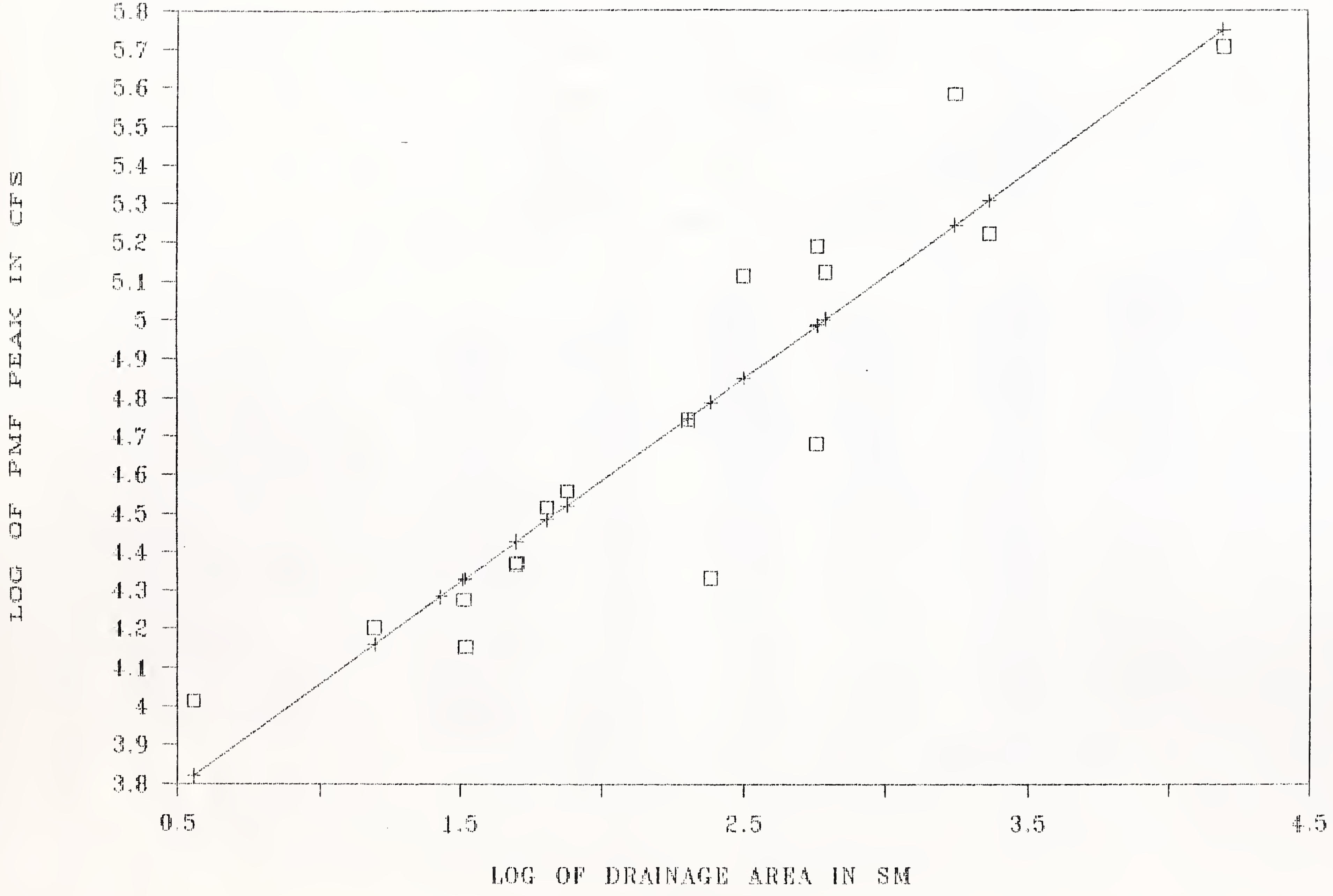
```
FILE:PMF3                                                  LOG
PMF ANALYSES                             ------------------------------
                         CFS       SM       SM       CFS   COMP CFS COMP CFS
                       -------  -------  -------  -------  -------  -------
CANYON FERRY            506000    15850    4.200    5.704    5.750   562030
CLARK CANYON            166800     2315    3.365    5.222    5.307   202880
TONGUE RIVER            382000     1760    3.246    5.582    5.244   175465
PETROLIA                132607      612    2.787    5.123    5.001   100277
GIBSON                  155000      575    2.760    5.190    4.987    97019
LIMA                     47900      570    2.756    4.680    4.985    96571
PAINTED ROCKS           130000      316    2.500    5.114    4.849    70657
RED ROCKS                21400      242    2.384    4.330    4.788    61346
COONEY                   55300      200    2.301    4.743    4.744    55454
SWIFT                    36000     75.3    1.877    4.556    4.519    33055
LAKE SHERBURNE           32700     63.7    1.804    4.515    4.481    30252
LOWER TWO MEDICINE       23500     50.2    1.701    4.371    4.426    26666
SOUTH SANDSTONE          23200     49.7    1.696    4.365    4.424    26525
COTTONWOOD               14200       33    1.519    4.152    4.329    21353
GARTSIDE                 18820     32.5    1.512    4.275    4.326    21181
MARTINSDALE              15942     15.7    1.196    4.203    4.159    14408
SHELL VALLEY             10300      3.6    0.556    4.013    3.820     6604
MIDDLE CREEK                         27    1.431             4.283    19200

                                 Log-Log  Regression Output:
                                 Constant                    3.525170
                                 Std Err of Y Est            0.205549
                                 R Squared                   0.851250 R=
                                 No. of Observations               17 0.922632
                                 Degrees of Freedom                15

                                 X Coefficient(s)  0.529660
                                 Std Err of Coef.  0.057167
```

FIGURE 1

PMF ANALYSES



Hyalite Creek in Western Montana (Elwell, 1988b). Regional data for both precipitation and streamflow are available for the 100-year recurrence interval, therefore, the 100-year event was used for calibration purposes. Attempts were made to calibrate both the USBR Rocky Mountain dimensionless unit hydrograph and the Clark unit hydrograph for the 100-year event.

The 100-year inflow at Middle Creek Dam was estimated to be 734 cfs (HKM, April 1984). Using the most recent USGS publication for estimating the magnitude of floods in Montana, the 100-year peak inflow was estimated to be approximately 870 cfs (Omang, May 1986). To be conservative, a 100-year flood peak of 870 cfs was used for calibration purposes.

Using the USBR's Rocky Mountain dimensionless unit hydrograph the Kn value was varied for calibration. The Kn had to be increased to approximately 0.9 to calibrate the model. The highest Kn value in the Rocky Mountains reported by the USBR is 0.34. This indicates the USBR Rocky Mountain dimensionless UHG is inappropriate for use in the Hyalite drainage. Using the Clark UHG the storage coefficient, R, was varied. Calibration was achieved with a R value of 27. This is well within the accepted range. Based on the calibration findings, the Clark UHG appears to be the better of the two UHG's for this analyses.

While the hydraulic efficiency would appear not to increase after Hyalite Creek overtops and flow enters the trees, an increase in the UHG peak of 25 to 50 percent can be anticipated in a typical basin (WMO, 1983). By decreasing the calibrated R of 27 down to R = 10, the UHG peak increased from 1091 cfs to 1596 cfs, or an increase of about 50 percent. Using this R value, the PMF peak is estimated to be 17,500 cfs. An R value of 10 was originally recommended by the COE for use on this project based on their work in the Sierra Nevadas which Design of Small Dams indicates is similar to the Rocky Mountains (Elwell, 1984 and USBR, 1987).

Based on the calibrated Clark UHG and the plot of PMF estimates the Middle Creek Dam spillways should be designed to safely pass a PMF of approximately 20,000 cfs.

REFERENCES

Elwell, G.E., 1984. Telephone communication with U.S. Army Corps of Engineers personnel. Sacramento, California.

Elwell, G.E., 1987. Telephone Communication with National Weather Service personnel. Washington, D.C.

Elwell, G.E., 1988a. Telephone communication with U.S. Bureau of Reclamation personnel. Denver, Colorado.

Elwell, G.E., 1988b. Telephone communication with U.S. Geological Survey personnel. Helena, Montana.

HKM Associates, April 1984. Flood Hydrology, Middle Creek Dam. Billings, Montana: HKM.

Omang, R.J., et.al. May 1986. Methods for Estimating Magnitude and Frequency of Floods in Montana Based on Data through 1983. Water-Resources Investigations Report 86-4027. Helena, Montana: U.S. Geological Survey.

U.S. Army Corps of Engineers. April 1982. Hydrologic Analysis of Ungaged Watersheds Using HEC-1. Training Document No. 15. Davis, California: Hydrologic Engineering Center.

U.S. Bureau of Reclamation, 1987. Design of Small Dams. Washington, D.C.: Government Printing Office.

World Meteorological Organization, 1983. Guide to Hydrological Practices, Volume II. WMO-No. 168. Geneva, Switzerland: The Organization.

APPENDIX B-3
FREEBOARD REQUIREMENTS

APPENDIX B-3

FREEBOARD REQUIREMENTS

Considerable discussion has taken place relative to the freeboard requirements for the Middle Creek Dam project. Freeboard requirements were originally estimated (HKM, 1984) using the publication Wave Runup and Wind Setup on Reservoir Embankments (McCartney, 1976) as recommended in Safety of Existing Dams, Evaluation and Improvement (NRC, 1983). It appears that the USBR has adopted the same procedure with a few modifications (USBR, December 1981).

Using the methods referenced above, the freeboard would be 2.3 feet and 2.1 feet adjacent to the conventional earth fill and the earth reinforced structure, respectively. The USBR publication indicates that for earthen embankments, the minimum freeboard should be three feet (USBR, December 1981). The same publication goes on to say that for existing dams, it is possible to encroach on this three feet of freeboard. This is because much of the uncertainty relative to meteorology, hydrology, settlement, and other related factors has been reduced. The increase in the height of the Middle Creek embankment is minor relative to the total height of the embankment, therefore, this project should be treated as an existing dam.

Additional discussions with the USBR indicate that the freeboard is usually selected based on discussions with meteorologists (Elwell, 1988a). Meteorologists can provide important information relative to the interaction between strong winds and storms of various types that is not generally available in the PMP and freeboard publications. Apparently, in some cases, the USBR has assumed zero freeboard where wind is expected to be minor during the PMF and/or not coming from a direction that would direct waves at the dam. Discussions with the SCS and NWS indicate that this type of situation applies at Middle Creek Dam (Elwell, 1988b and Elwell, 1988c). These sources feel that winds during a 72-hour general-storm PMP would be minor and would come out of the east. These winds would have a minor impact on Middle Creek Dam which is located at the north end of the reservoir. They went on to say that the most significant winds that would develop at this site would accompany thunderstorms in which the winds would precede the rainfall and resulting maximum pool levels.

The magnitude of the PMF has not been finalized, however, routing results indicate that a 5 foot blockage at the end of the auxiliary spillway transition will not affect the auxiliary spillway rating curve.

The proposed Middle Creek Dam embankment is surfaced with approximately 12 inches of gravel. This gravel will serve as the subgrade for the asphalt driving surface to be applied shortly after this project is completed. The maximum water surface obtained by routing the PMF should remain below the top of the impervious zone (USBR, December 1981).

This is an existing dam for which there is a low level of uncertainty and winds should not reasonably be expected to be a factor when maximum reservoir levels are present. In addition, flood routing was performed with the outlet works closed which adds additional conservatism. Therefore, Middle Creek Dam should be designed for zero feet of freeboard with the maximum water surface resulting from routing the PMF equal to the top of the impervious zone.

REFERENCES

Elwell, G.E. 1988a. Telephone communication with U.S. Bureau of Reclamation personnel. Denver, Colorado.

Elwell, G.E. 1988b. Telephone communication with U.S. Soil Conservation Service personnel. Bozeman, Montana.

Elwell, G.E. 1988c. Telephone communication with National Weather Service personnel. Helena, Montana.

HKM Associates. April 1, 1987 Middle Creek Dam Rehabilitation. Billings, Montana: HKM.

McCartney, Bruce L. November 1976. Wave Runup and Wind Setup on Reservoir Embankments. ETL 1110-221. Washington, D.C.: U.S. Army Corps of Engineers.

National Research Council. 1983. Safety of Existing Dams, Evaluation and Improvement. Washington, D.C.: National Academy Press.

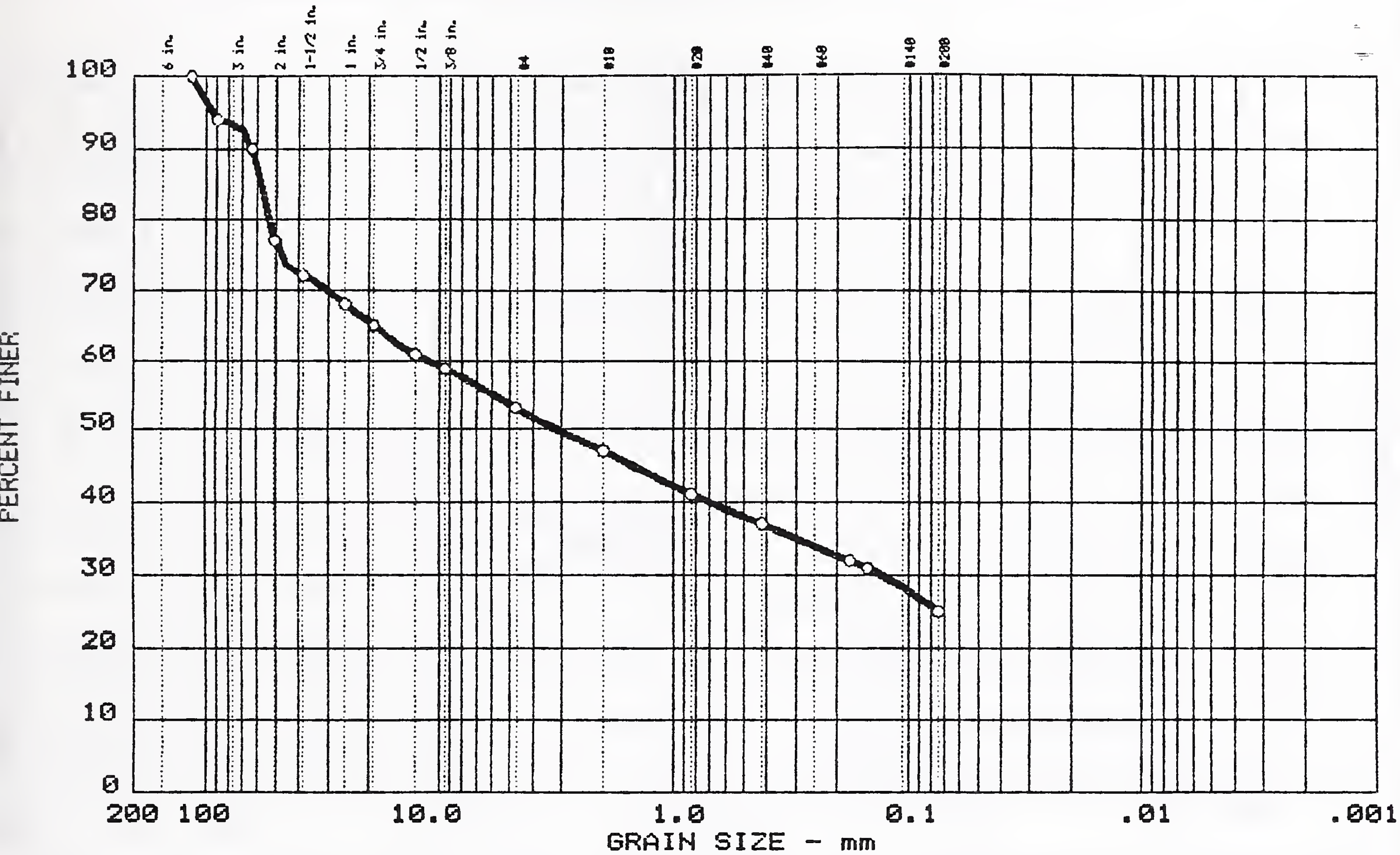
U.S. Bureau of Reclamation. December 1981. Freeboard Criteria and Guidelines for Computing Freeboard Allowances for Storage Dams. ACER Technical Memorandum No. 2. Denver, Colorado: The Bureau.

APPENDIX C

GEOTECHNICAL TEST RESULTS

APPENDIX C-1
GEOTECHNICAL TEST RESULTS

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
6	6.5	40.5	28.0	25.0	

LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
Gran.	N.P.	58.01	10.93	3.15	0.128				

MATERIAL DESCRIPTION	USCS	AASHTO
○ Silty gravel with sand	GM	A-1-b

Project No.: 8M087.132
Project: Middle Creek Dam
○ Location: TP-303 @ 1.0' - 6.0'

Date: 2-17-88

Remarks:

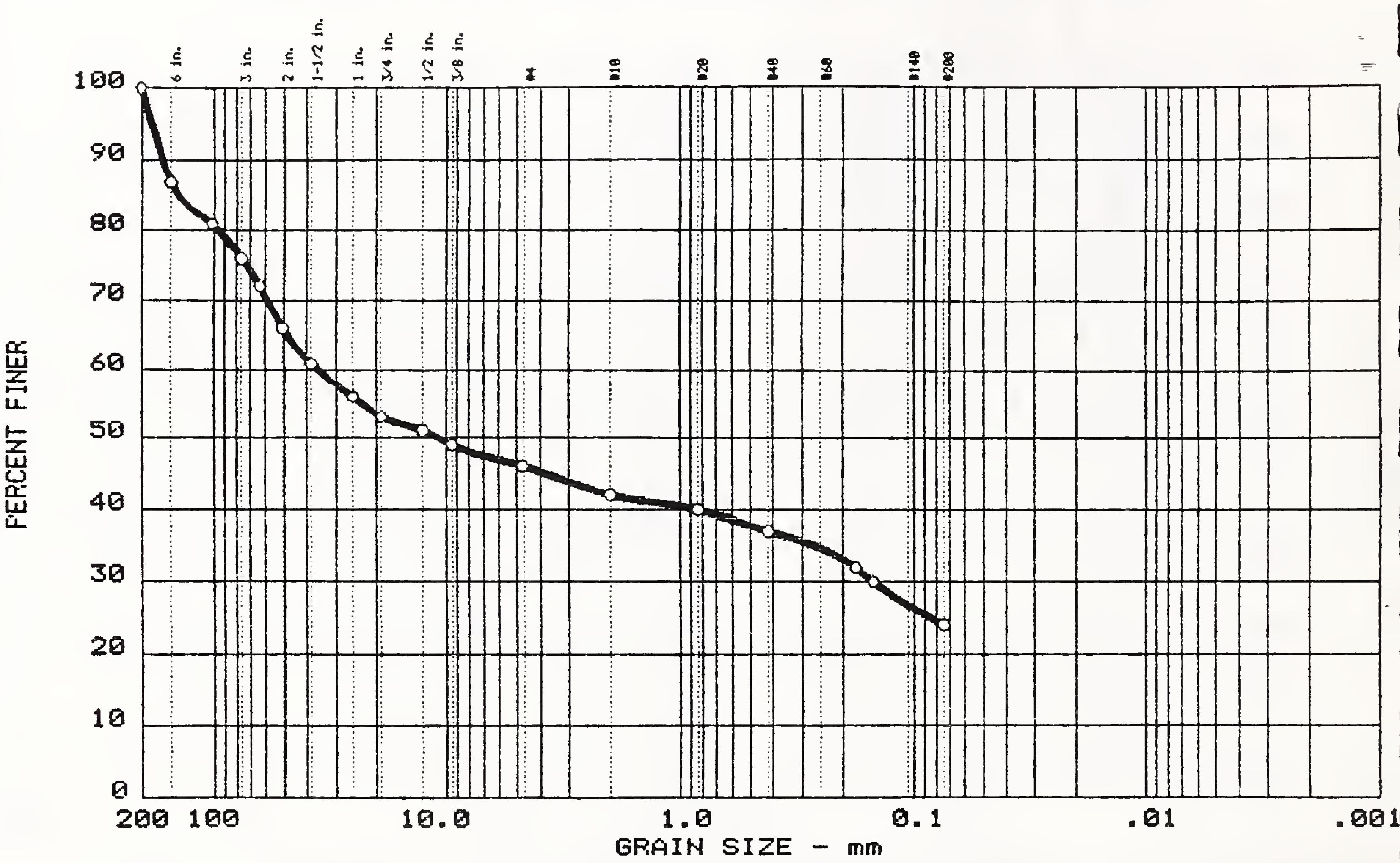
Lab # 5444.

Sampled by H.K.M.

GRAIN SIZE DISTRIBUTION TEST REPORT
H.K.M. ASSOCIATES

Fig. No. 1

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	7	24.0	30.0	22.0	24.0	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	34	16	140.93	34.99	10.94	0.148				

MATERIAL DESCRIPTION	USCS	AASHTO
○ Clayey gravel with sand	GC	A-2-6

Project No.: 8M087.132
Project: Middle Creek Dam
○ Location: TP-308 @ 1.5' - 6.0'

Date: 2-17-88

Remarks:

Lab # 5446.

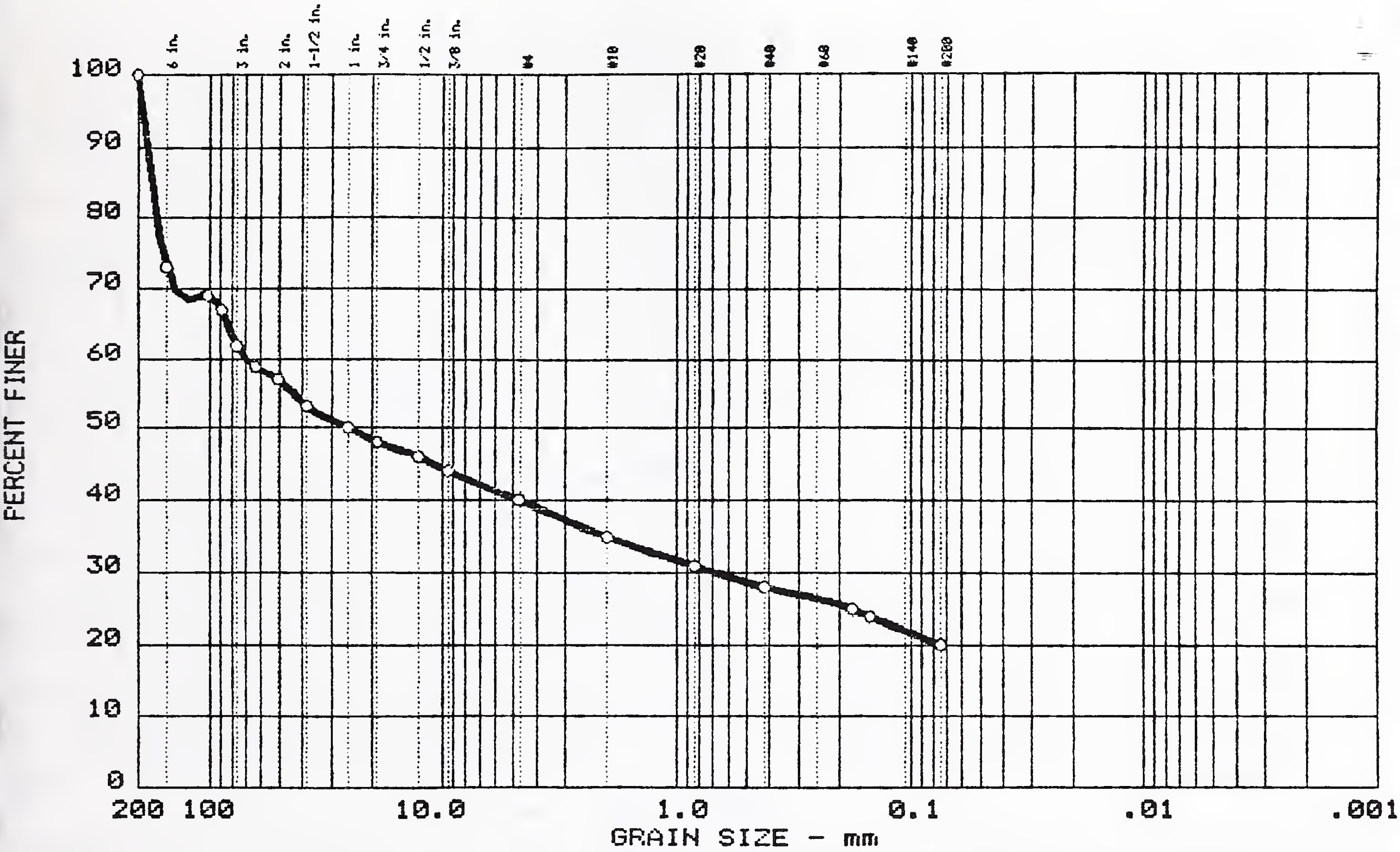
Sampled by H.K.M.

GRAIN SIZE DISTRIBUTION TEST REPORT

H.K.M. ASSOCIATES

Fig. No. 2

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
8	38.0	22.0	20.0	20.0	

LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
33	17	177.01	68.87	25.29	0.665				

MATERIAL DESCRIPTION	USCS	AASHTO
○ Clayey gravel with sand	GC	A-2-6

Project No.: 8M087.132
Project: Middle Creek Dam
○ Location: TP-311 @ 1.0' - 5.0'

Date: 2-17-88

Remarks:

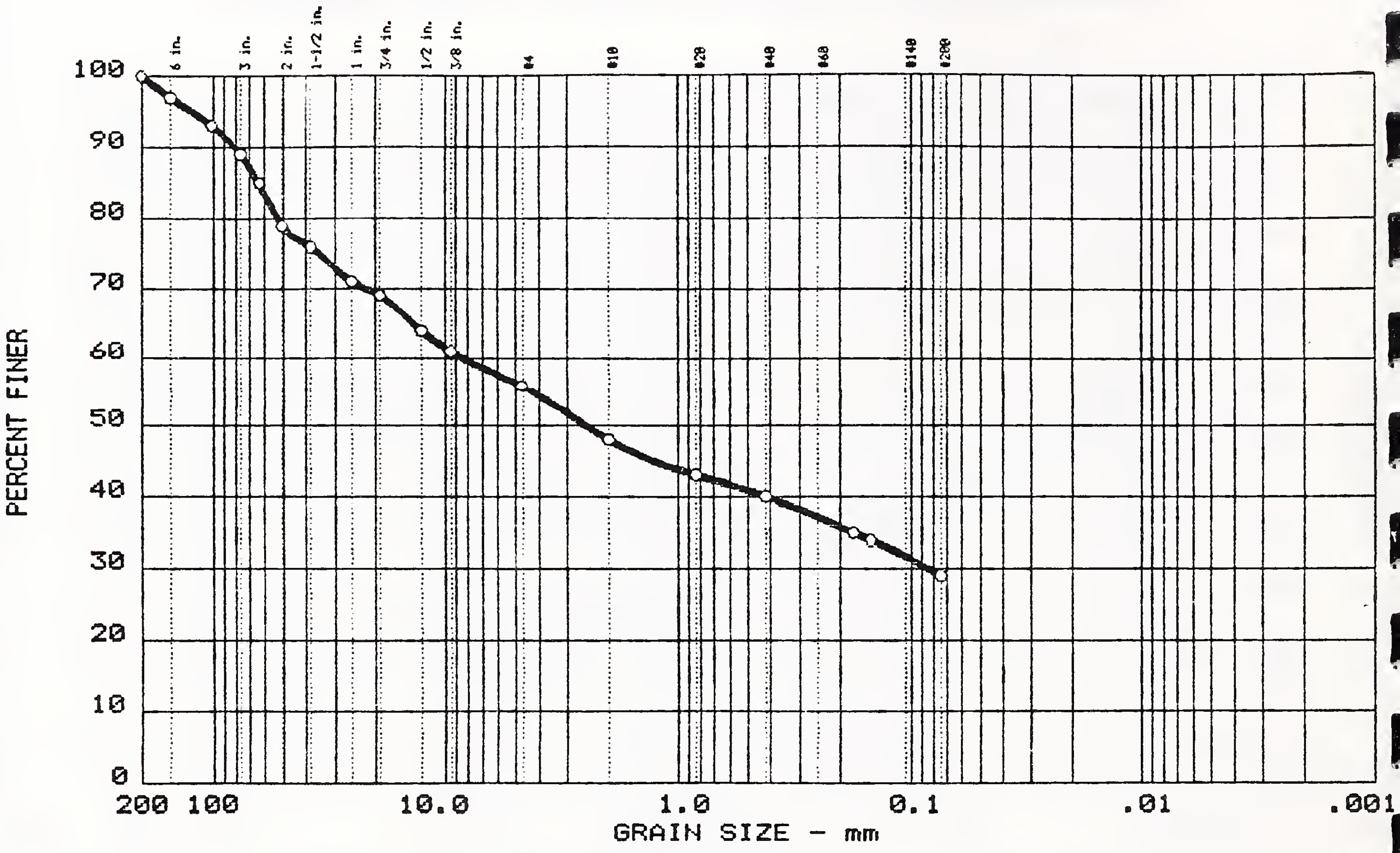
Lab # 5449.

Samoled by H.K.M.

GRAIN SIZE DISTRIBUTION TEST REPORT
H.K.M. ASSOCIATES

Fig. No. 3

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	9	11.0	33.0	27.0	29.0	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	33	17	63.10	8.32	2.48	0.083				

MATERIAL DESCRIPTION	USCS	AASHTO
○ Clayey gravel with sand	GC	A-2-6

Project No.: 8M087.132
Project: Middle Creek Dam
○ Location: TP-312 @ 6.0' - 8.0'

Date: 2-17-88

Remarks:

Lab # 5452.

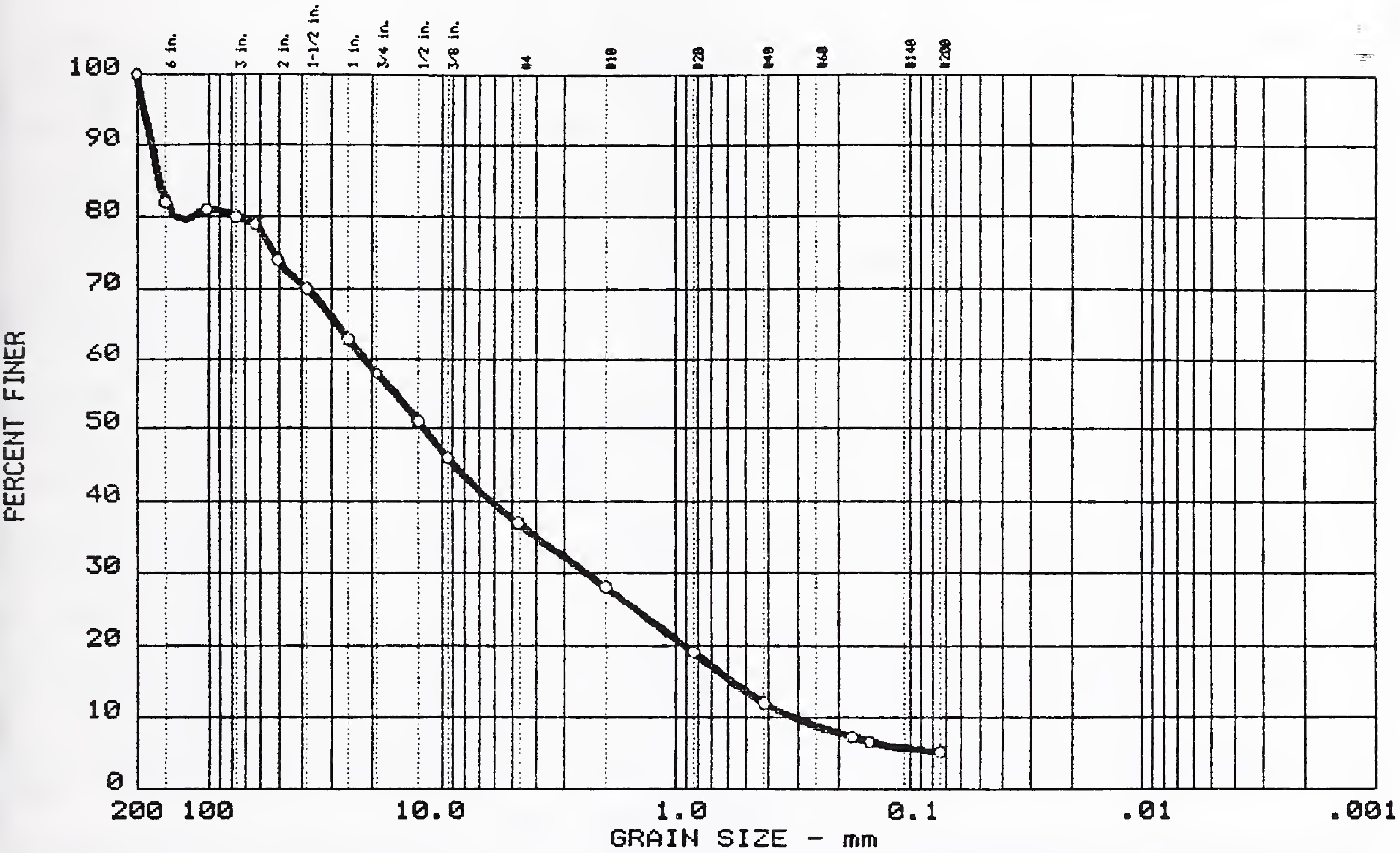
Sampled by H.K.M.

GRAIN SIZE DISTRIBUTION TEST REPORT

H.K.M. ASSOCIATES

Fig. No. 4

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	10	20.0	43.0	31.8	5.2	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	Gran.	N.P.	163.12	21.26	11.95	2.413	0.5788	0.3108	0.88	68.4

MATERIAL DESCRIPTION	USCS	AASHTO
○ Poorly graded gravel with silt and sand	GP-GM	A-1-a

Project No.: 8M087.132
Project: Middle Creek Dam
○ Location: TP-313 @ 4.0' - 6.0'

Date: 2-17-88

Remarks:

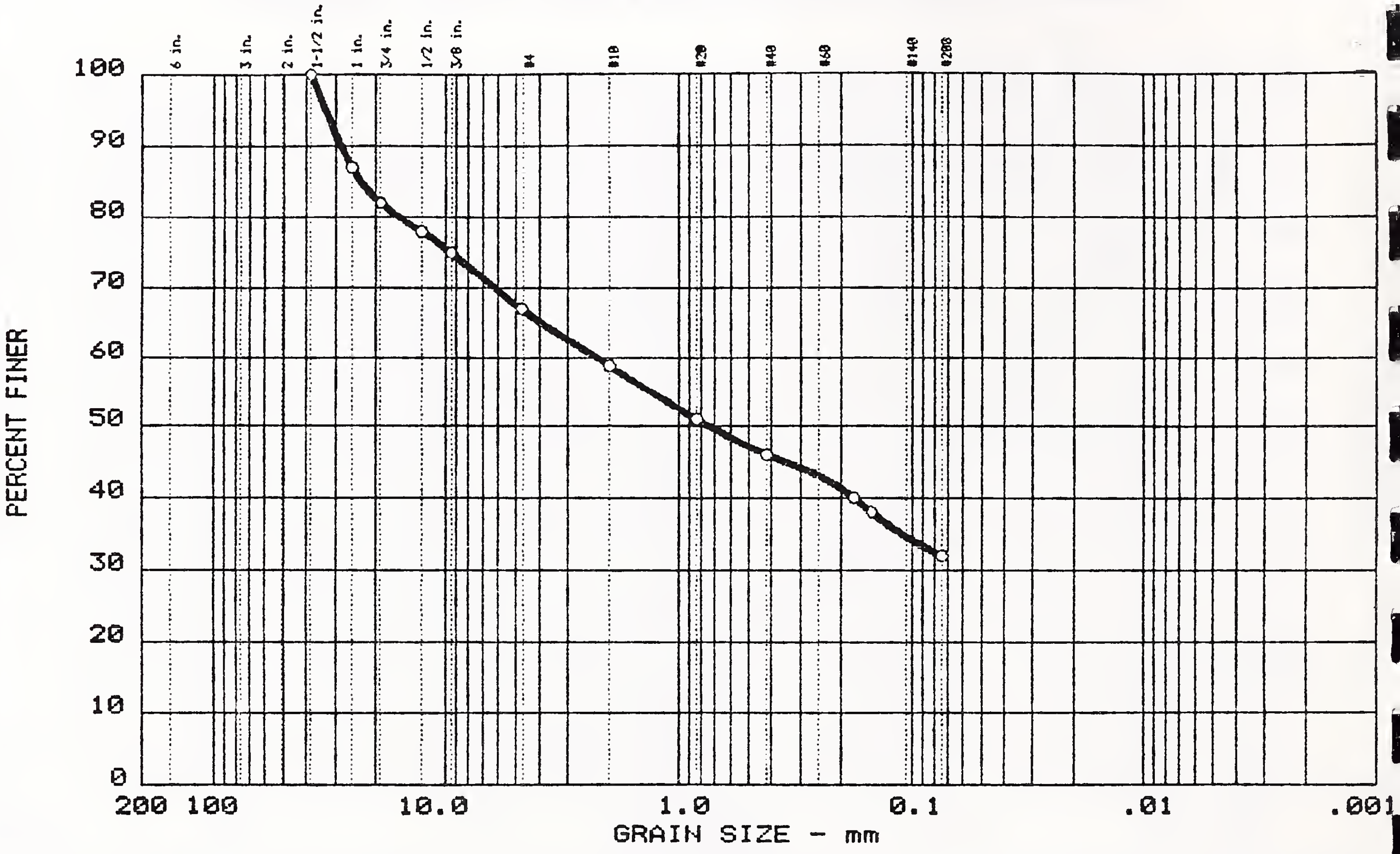
Lab # 5453.

Sampled by H.K.M.

GRAIN SIZE DISTRIBUTION TEST REPORT
H.K.M. ASSOCIATES

Fig. No. 5

GRAIN SIZE DISTRIBUTION TEST REPORT



	Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○	11	0.0	33.0	35.0	32.0	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	33	13	22.91	2.21	0.74					

MATERIAL DESCRIPTION	USCS	AASHTO
○ Clayey sand with gravel	SC	A-2-6

Project No.: 8M087.132
Project: Middle Creek Dam
○ Location: DH-201 @ 0.0' - 1.5' & 6.0' - 7.5'

Date: 2-17-88

Remarks:

Lab # 5496/5497 Combo.

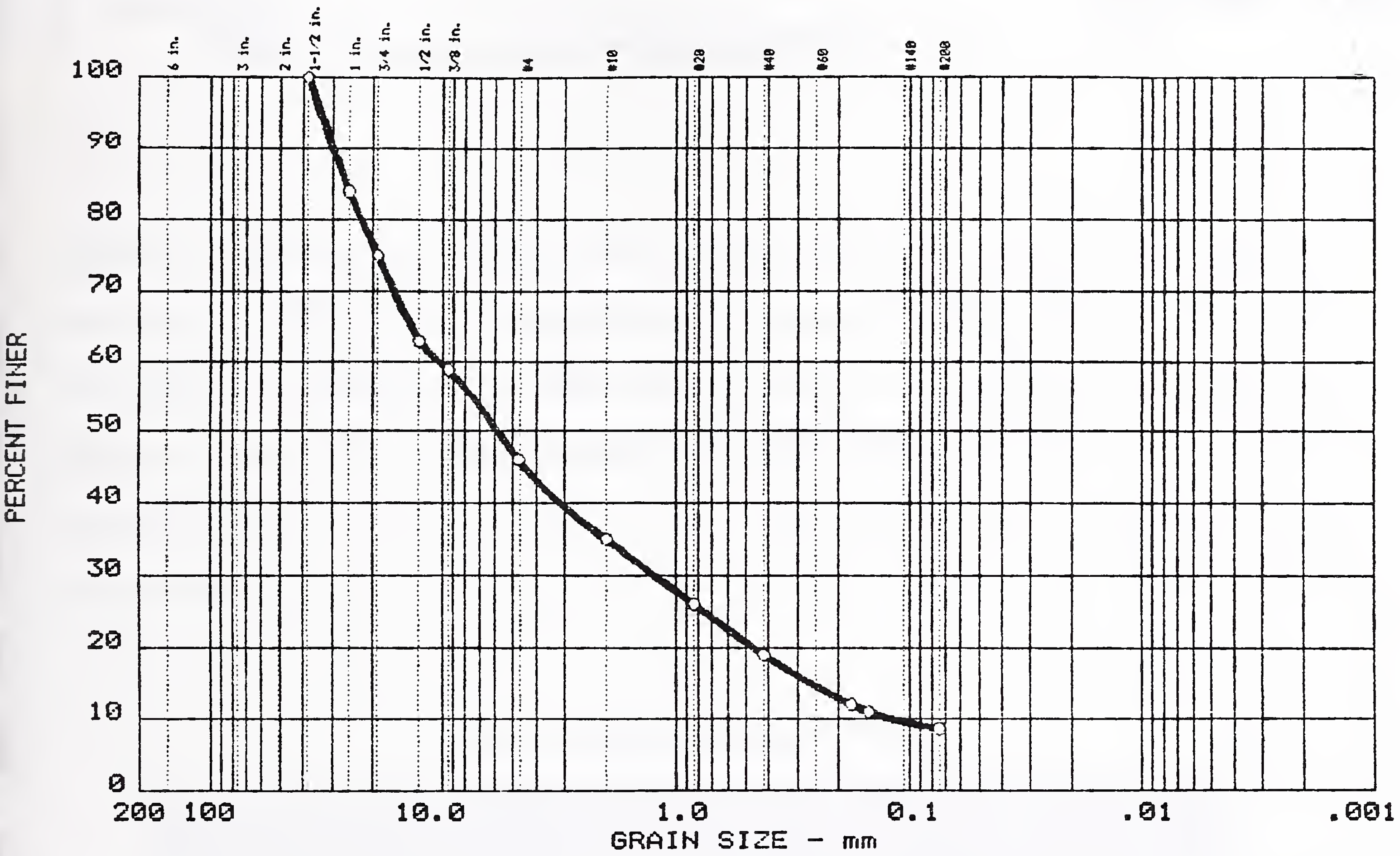
Sampled by H.K.M.

GRAIN SIZE DISTRIBUTION TEST REPORT

H.K.M. ASSOCIATES

Fig. No. 6

GRAIN SIZE DISTRIBUTION TEST REPORT



Test	%+3"	% GRAVEL	% SAND	% SILT	% CLAY
○ 12	0.0	54.0	37.3	8.7	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○	Gran.	N.P.	26.00	10.23	5.82	1.230	0.2630	0.1175	1.26	87.1

MATERIAL DESCRIPTION	USCS	AASHTO
○ Well-graded gravel with silt and sand	GW-GM	A-1-a

Project No.: 8M087.132
Project: Middle Creek Dam
○ Location: DH-206 @ 30.0' - 31.5'

Date: 2-17-88

GRAIN SIZE DISTRIBUTION TEST REPORT
H.K.M. ASSOCIATES

Remarks:

Lab # 5498.

Sampled by H.K.M.

Fig. No. 7

HKM ASSOCIATES
ENGINEERS · PLANNERS

MOISTURE DENSITY RELATIONS OF SOILS

Project No. 8M087.136

Lab No. TP-308 (1.5 - 6.0')

Project Name Middle Creek Dam

Test Designation ASTM D 698

Date Sampled 11-24-87

Date Tested 6-10-88

Soil Class. TILL, CLAYEY GRAVEL with SAND

% Passing # 4Sieve 24

Maximum Dry Density 119.0 pcf

Optimum Moisture 13.6%

MOISTURE-DENSITY GRAPH

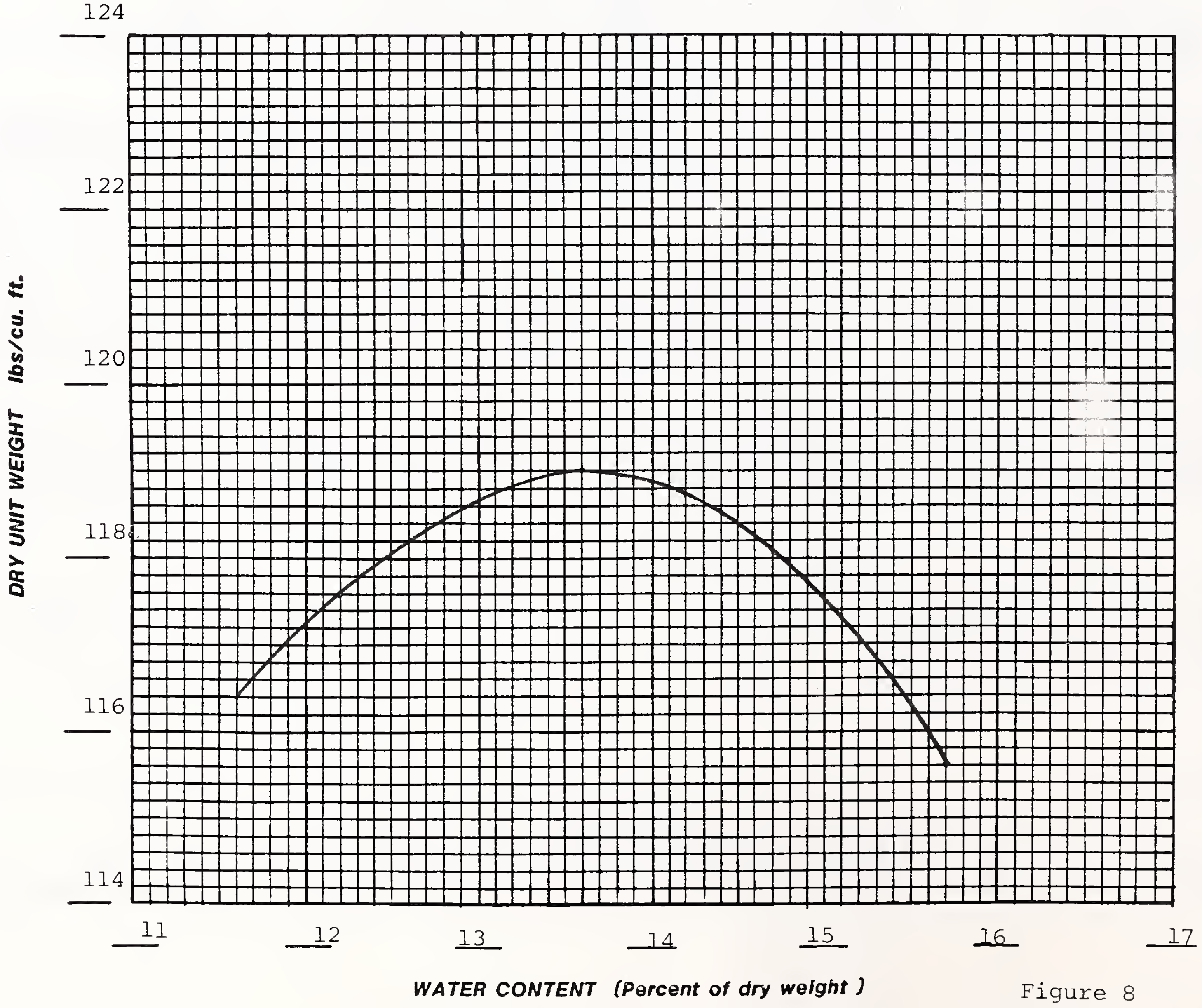


Figure 8

MOISTURE DENSITY RELATIONS OF SOILS

Project No.	8M087.136	**Lab No.**	TP-312 (5.0 - 8.0')
Project Name	Middle Creek Dam	**Test Designation**	ASTM D 698
Date Sampled	11-24-87	**Date Tested**	1-26-88
Soil Class.	TILL, CLAYEY GRAVEL with SAND	**% Passing # 4Sieve**	29
Maximum Dry Density	121.0 pcf		
Optimum Moisture	13.4%		

MOISTURE-DENSITY GRAPH

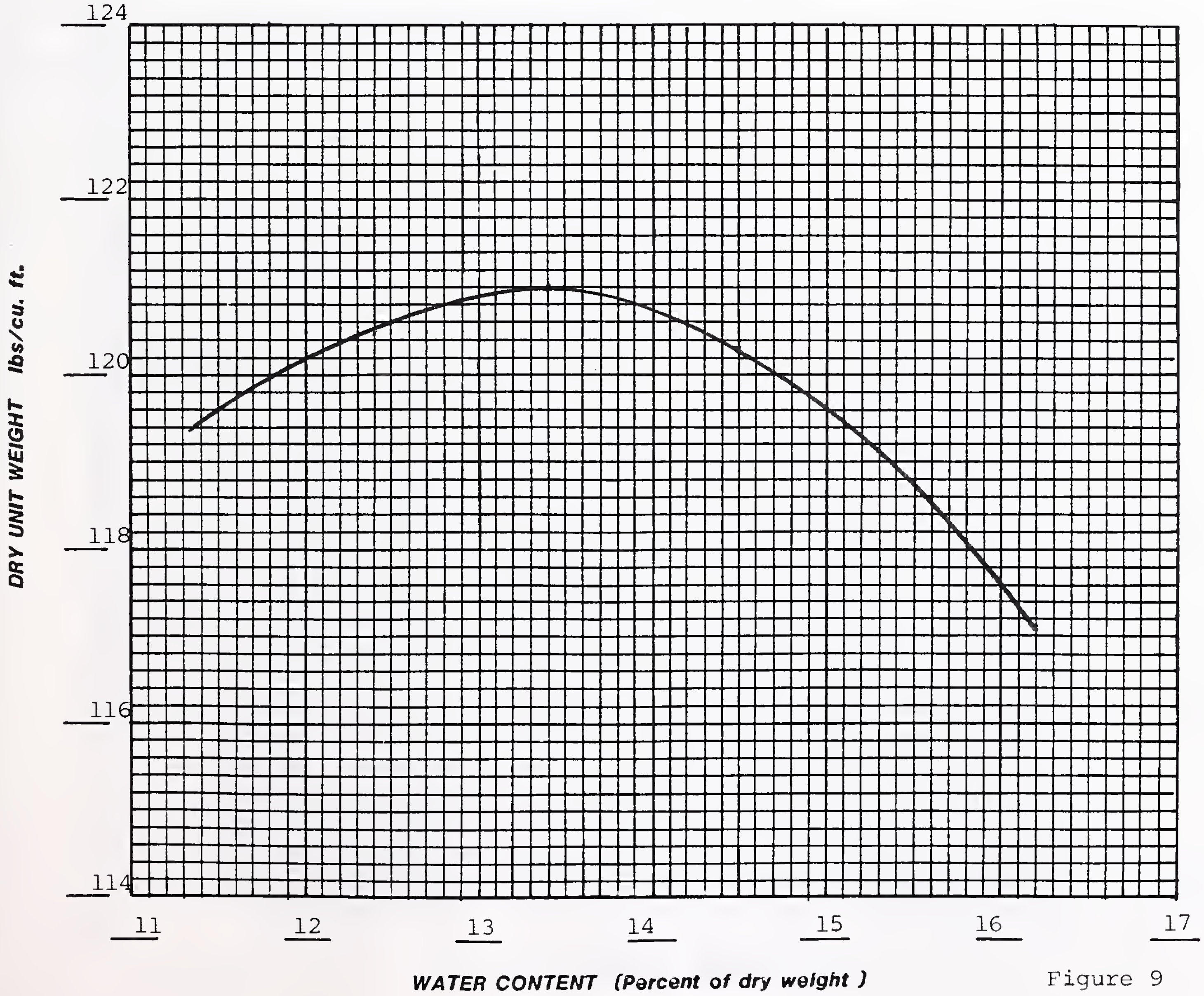


Figure 9

HKM ASSOCIATES
ENGINEERS · · PLANNERS

MOISTURE DENSITY RELATIONS OF SOILS

Project No. 8M087.136

Lab No. TP-313 (4.0 - 6.0')

Project Name Middle Creek Dam

Test Designation ASTM D 698

Date Sampled 11-24-87

Date Tested 1-26-88

Soil Class. TILL POORLY GRADED GRAVEL with SILT & SAND

% Passing # 4Sieve 5

Maximum Dry Density 131.4 pcf

Optimum Moisture 11.0%

MOISTURE-DENSITY GRAPH

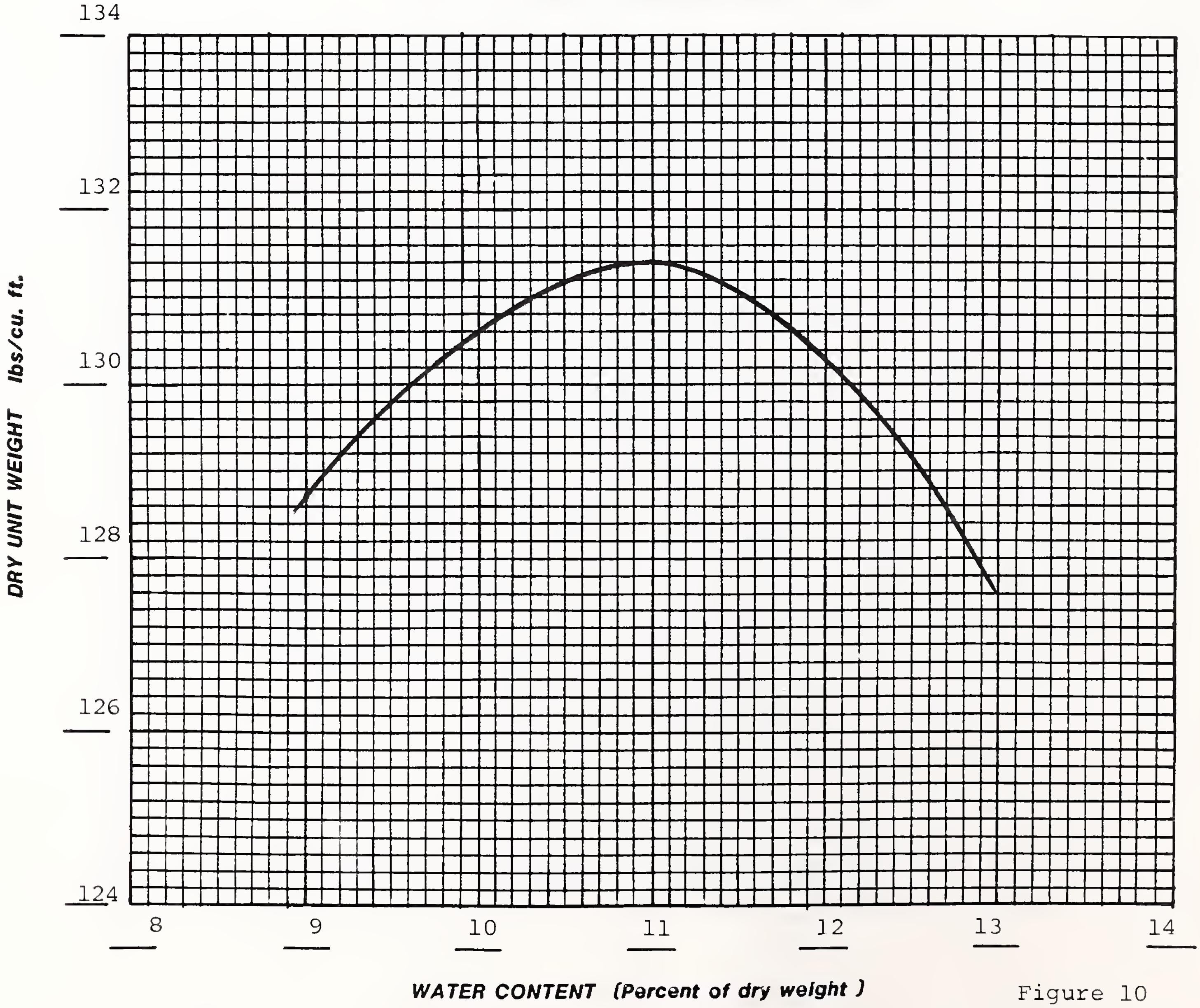


Figure 10

HKM ASSOCIATES
ENGINEERS · · PLANNERS

BEARING RATIO TEST

Project No. 8M087.136
Project Name Middle Creek Dam
Date Sampled 11-24-87
Sampled By DLD
Sample Location Auxiliary Spillway

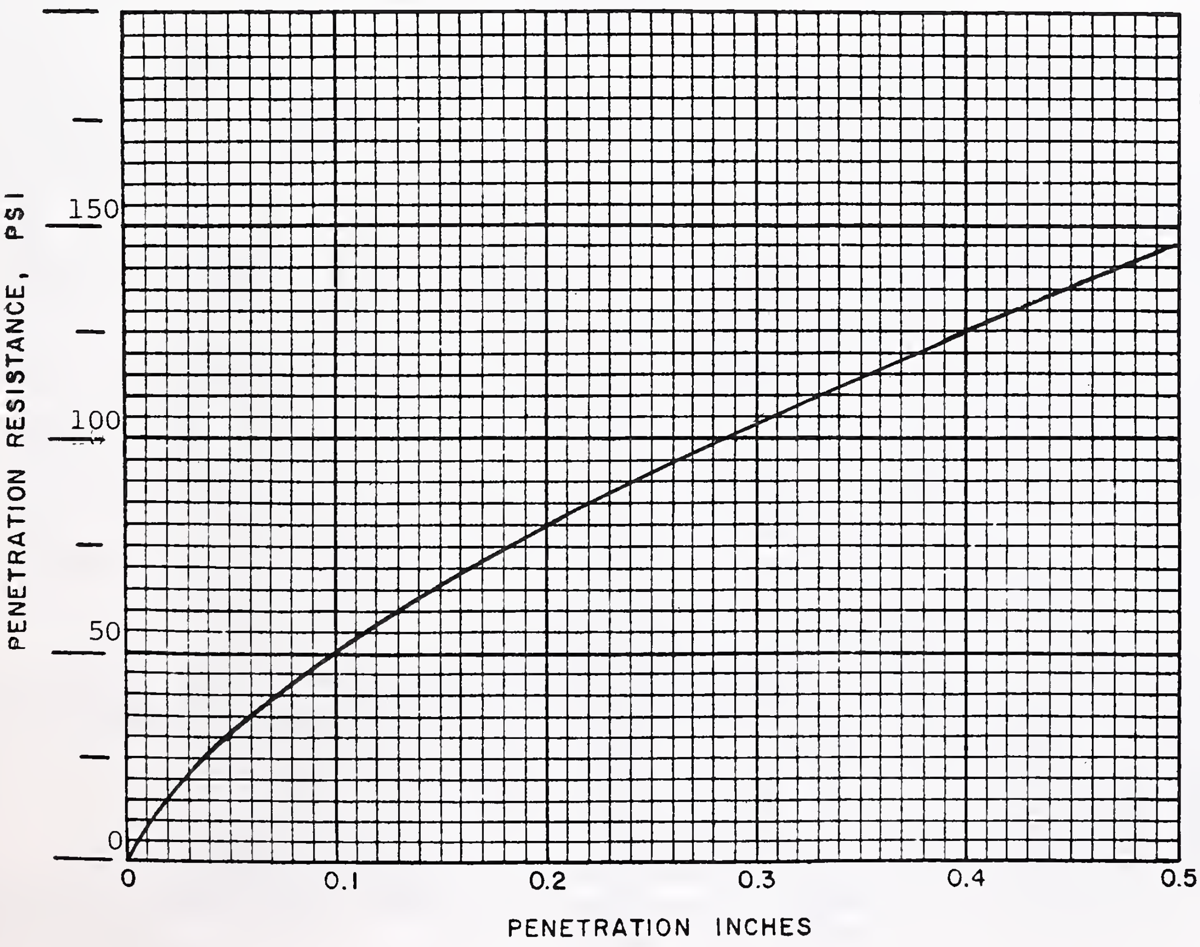
Lab No. 5546
Field No. TP 308 (1.5 - 6.0')
Date Tested 6-22-88
Tested By JP

PENETRATION INCHES	SURCHARGE 12.7 LBS.	
	PISTON LOAD DIAL READING	LOAD PSI
0.000	0	0
0.025	28	19
0.050	48	32
0.075	62	42
0.100	74	50
0.125	85	57
0.150	96	65
0.175	106	71
0.200	117	79

PENETRATION INCHES	SURCHARGE 12.7 LBS.	
	PISTON LOAD DIAL READING	LOAD PSI
0.300	154	104
0.400	185	125
0.500	221	150

WET WT. OF SOIL	583.9
DRY WT. OF SOIL	486.8
WT. OF WATER	97.1
FINAL MOISTURE CONTENT	20.0%

SAMPLE REMOLDED AT 94.5% MAXIMUM DRY DENSITY
16.0% MOISTURE CONTENT



BEARING RATIO = 5

Figure 11

HKM ASSOCIATES
ENGINEERS · · PLANNERS

BEARING RATIO TEST

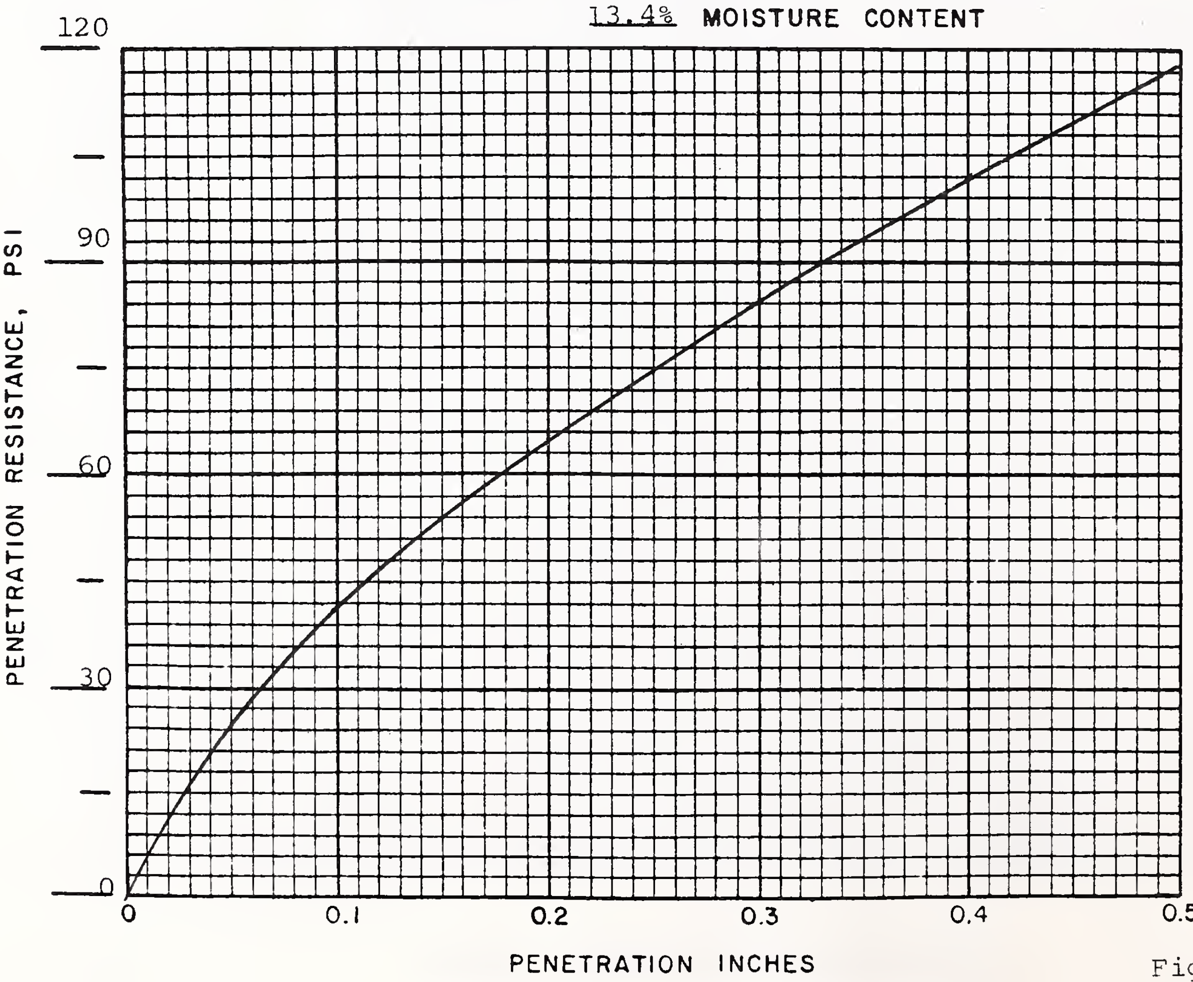
Project No. 8M087.136
Project Name Middle Creek Dam
Date Sampled 11-24-87
Sampled By DLD
Sample Location Auxiliary Spillway
Lab No. 5452
Field No. TP 312 (6.0 -8.0')
Date Tested 6-14-88
Tested By JP

PENETRATION INCHES	SURCHARGE 12.7 LBS.	
	PISTON LOAD DIAL READING	LOAD PSI
0.000	0	0
0.025	24	16
0.050	38	26
0.075	51	34
0.100	60	40
0.125	69	46
0.150	81	55
0.175	89	60
0.200	96	64

PENETRATION INCHES	SURCHARGE 12.7 LBS.	
	PISTON LOAD DIAL READING	LOAD PSI
0.300	127	85
0.400	152	102
0.500	169	113

WET WT. OF SOIL	718.0
DRY WT. OF SOIL	612.0
WT. OF WATER	106.0
FINAL MOISTURE CONTENT	17.3%

SAMPLE REMOLDED AT 95 % MAXIMUM DRY DENSITY
13.4% MOISTURE CONTENT



BEARING RATIO = 4

Figure 12

DIRECT SHEAR TEST

PROJECT NAME Middle Creek Dam

PROJECT # 8M087.136

LAB # 5452

FIELD # TP 312 (6.0 - 8.0')

SOIL CLASSIFICATION TILL CLAYEY GRAVEL with SAND

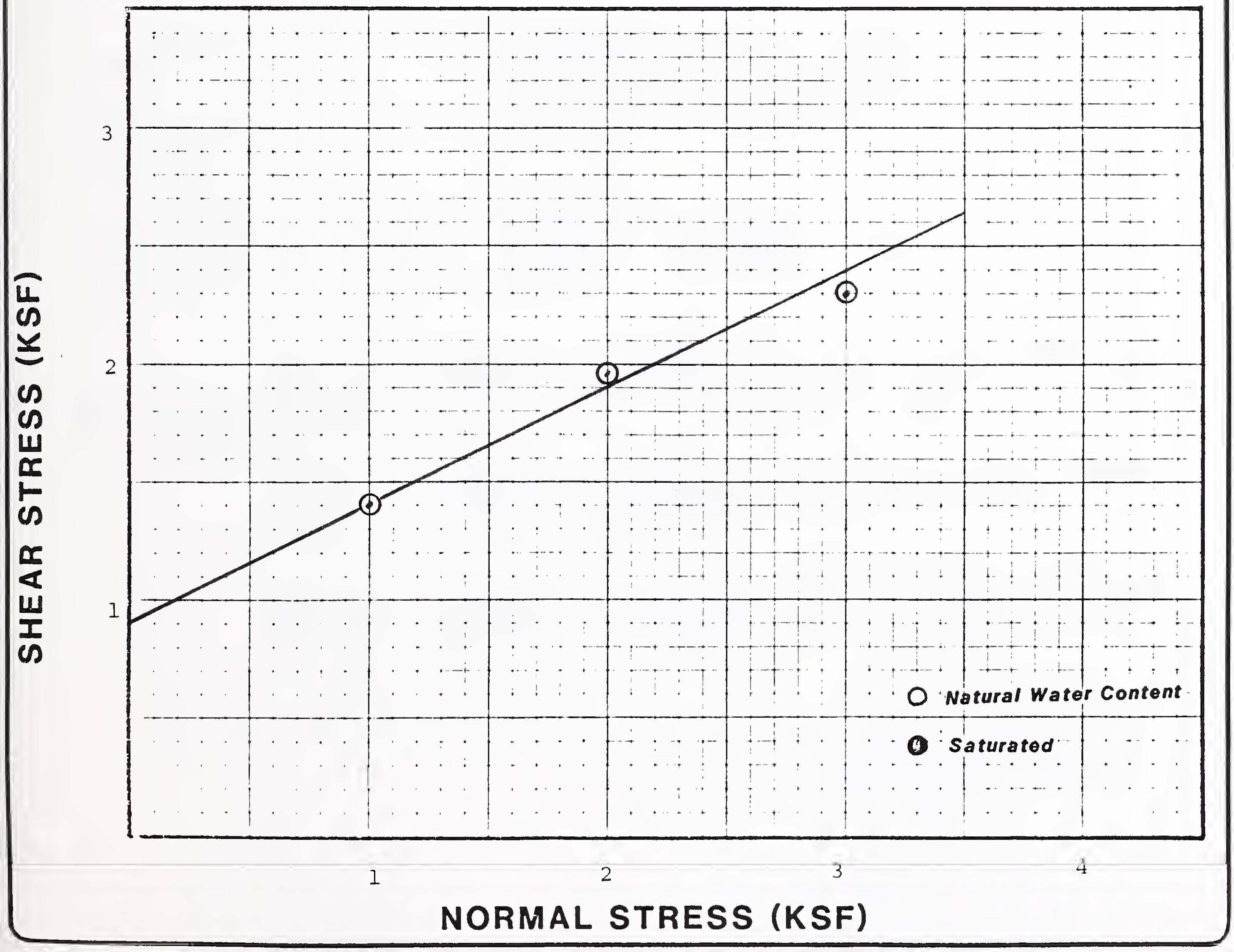
SHEAR RATE .038 in/min

DRY UNIT WEIGHT 118.3 pcf

NATURAL WATER CONTENT 13.4

FRICTION ANGLE 26.0°

COHESION INTERCEPT 900 psf



Middle Creek Dam Project
Earth Reinforced Structure Design

Figure 13

HKM ASSOCIATES
ENGINEERS · PLANNERS
8M087.136 | Aug, 1988

SPECIFIC GRAVITY OF COARSE AGGREGATE

PROJECT NO. 8M087.132
LAB NO. RIP RAP SOURCE
PROJECT NAME MIDDLE CREEK DAM
SOURCE
DESCRIPTION
DATE TESTED 12/30/87
MATERIAL
TESTED BY JBP

SAMPLE DATA Basket tare = 1615 Grs.

A - OVEN DRY 3399
B - S.S.D. IN AIR 3423 (NO TARE)
C - SATURATED IN WATER 3760-1615 = 2145

BULK SPECIFIC GRAVITY $= \frac{A}{B-C} = \frac{3399}{3423-2145} = \frac{3399}{1278} = 2.660$

BULK SPECIFIC GRAVITY S.S.D. $= \frac{B}{B-C} = \frac{3423}{3423-2145} = \frac{3423}{1278} = 2.678$

APPARENT SPECIFIC GRAVITY $= \frac{A}{A-C} = \frac{3399}{3399-2145} = \frac{3399}{1254} = 2.711$

ABSORPTION PERCENT $= \frac{B-A \times 100}{A} = \frac{3423-3399}{3399} = \frac{24}{3399}$ 0.71 %

TESTED IN ACCORDANCE WITH ASTM C127-73

Figure 14

INTERMOUNTAIN MATERIALS TESTING, INC.
7446 Lemhi St., Boise, Idaho 83709
2008 4th Ave. E., Twin Falls, Idaho 83301
376-8203
734-1293

Materials Engineering and Testing • Construction Inspection • Project Consultation

REPORT TO: HKM Associates
P.O. Box 31318
Billings, Montana 59107

DATE: 12-7-87
FILE NUMBER: 85-56
SHEET: 1 of 1
INVOICE: 871278

PROJECT: Middlecreek Dam

Sample Identification

On December 2, 1987, we received at our labortory a sample of aggregate reported to be from the above referenced project.

At your request, we performed a Los Angeles Abrasion in accordance with ASTM C535.

The test results are summarized as follows:

Test Results

	Lab No. 874331
Los Angeles Abrasion wear, %	12.2

Reviewed by:

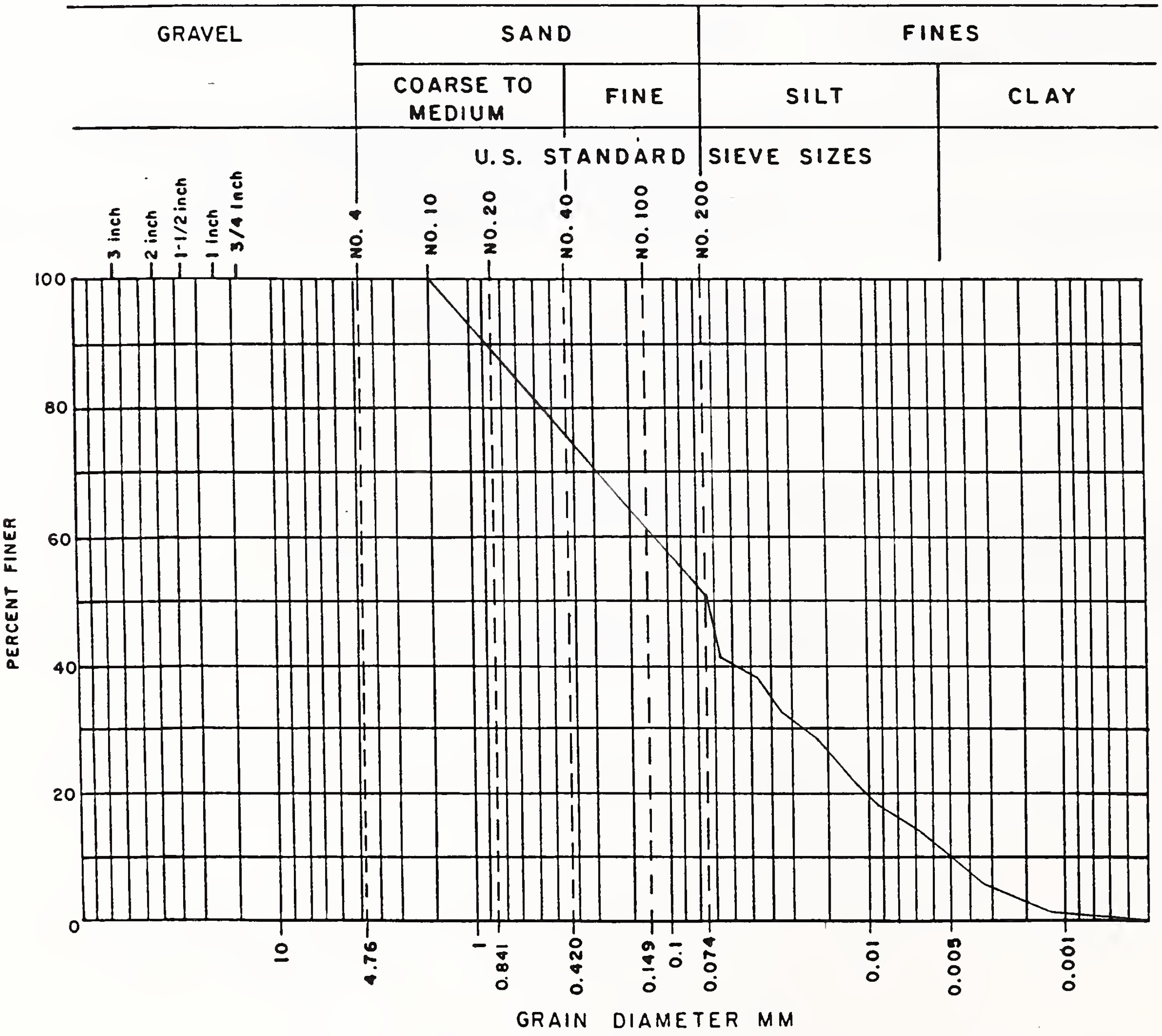
Figure 15

FORM ST-5-80
2869

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 2869
PROJECT NAME Middle Creek Dam
FIELD NO. DH-2 (20.0-22.0')
DATE SAMPLED 8-3-83
DATE TESTED 9-23-83
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Drive
SAMPLE LOCATION Bridge Abutment
SOIL DESCRIPTION SANDY SILT (ML)



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve 0 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 49 %
3)_ SILT & CLAY, Passing no. 200 sieve 51 %

Liquid Limit = 33%
Plastic Index = 4

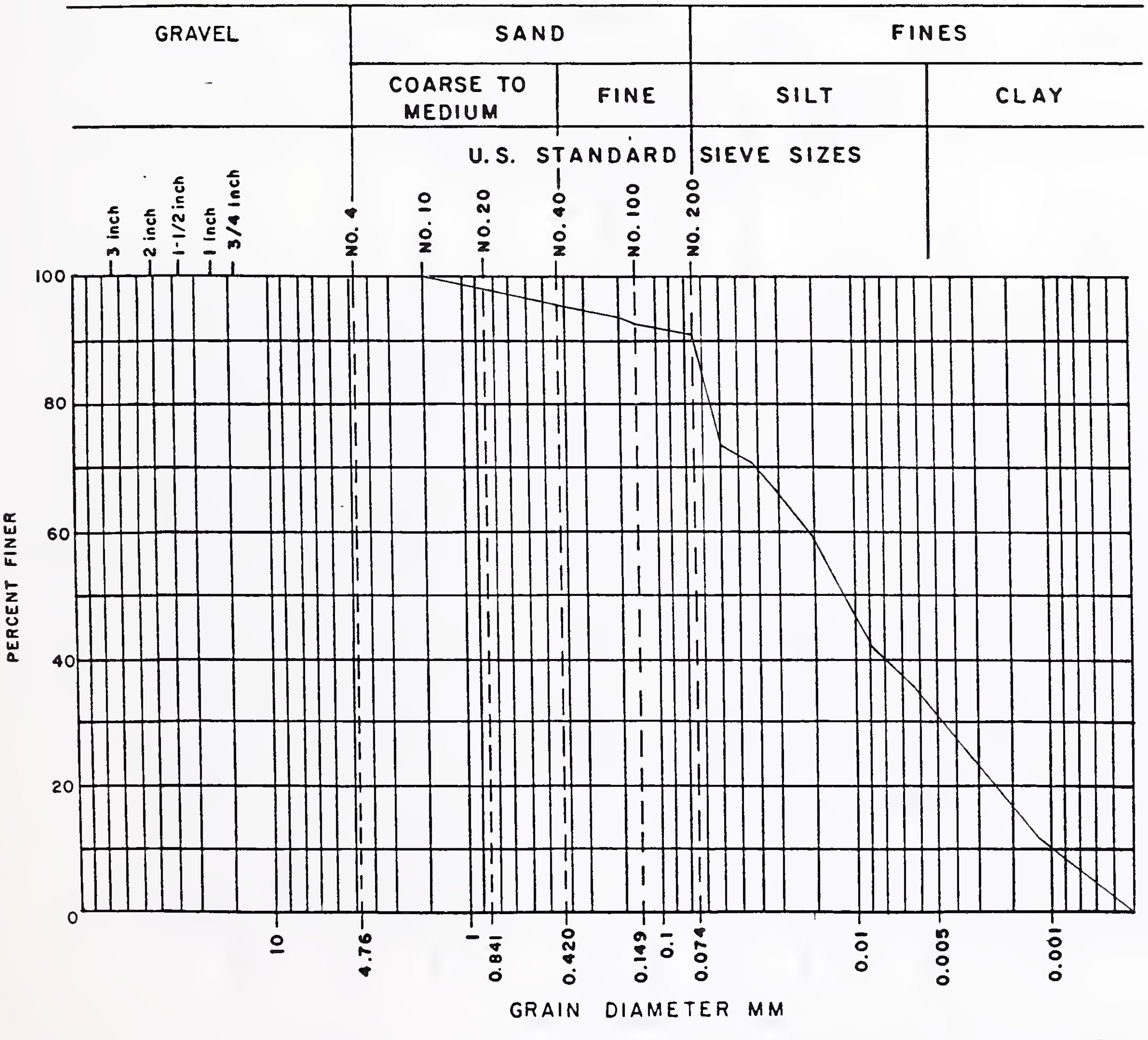
Plate No. 1

FORM ST-5-80
2896

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113 LAB NO. 2896
PROJECT NAME Middle Creek Dam FIELD NO. DH-4 (103.8-104.8')
DATE SAMPLED 8-10-83 DATE TESTED 9-21-83
SAMPLED BY DN TESTED BY CS
TYPE SAMPLE Core SAMPLE LOCATION Bedrock at
SOIL DESCRIPTION CLAYSTONE SHALE (CL-2) Downstream



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve 0 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 8 %
3)_ SILT & CLAY, Passing no. 200 sieve 92 %

Liquid Limit = 49%
Plastic Index = 21

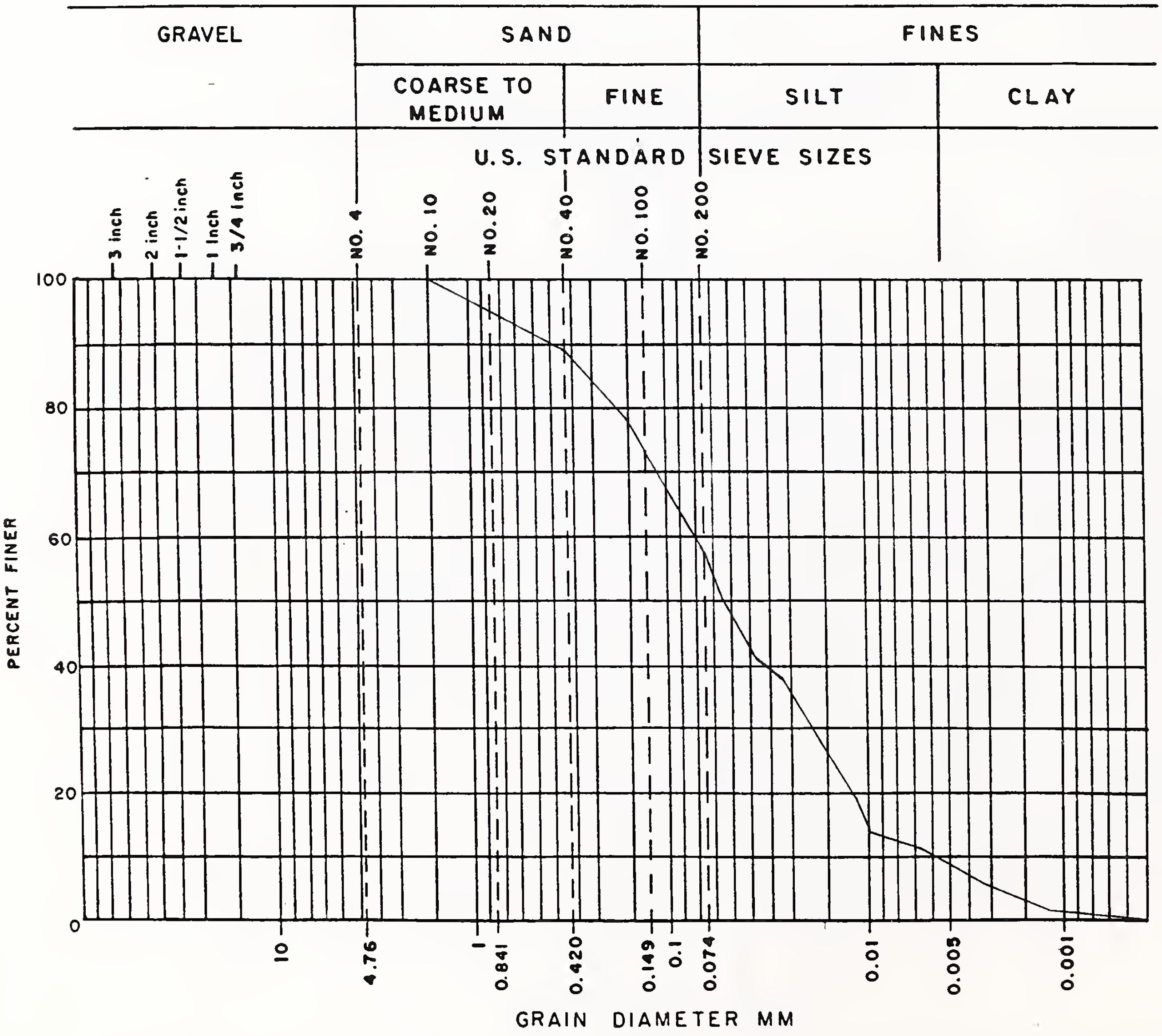
Plate No. 2

FORM ST-5-80
2912

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 2912
PROJECT NAME Middle Creek Dam
FIELD NO. DH-6 (10.0-12.0')
DATE SAMPLED 8-3-83
DATE TESTED 9-23-83
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Drive
SAMPLE LOCATION Semi-pervious Zone
SOIL DESCRIPTION SANDY SILT (ML)



1)– GRAVEL, Passing 3" & retained on no. 4 sieve ___0___%
2)– SAND, Passing no. 4 sieve & retained on no. 200 sieve. ___42___%
3)– SILT & CLAY, Passing no. 200 sieve ___58___%

Liquid Limit = 31%
Plastic Index = 4

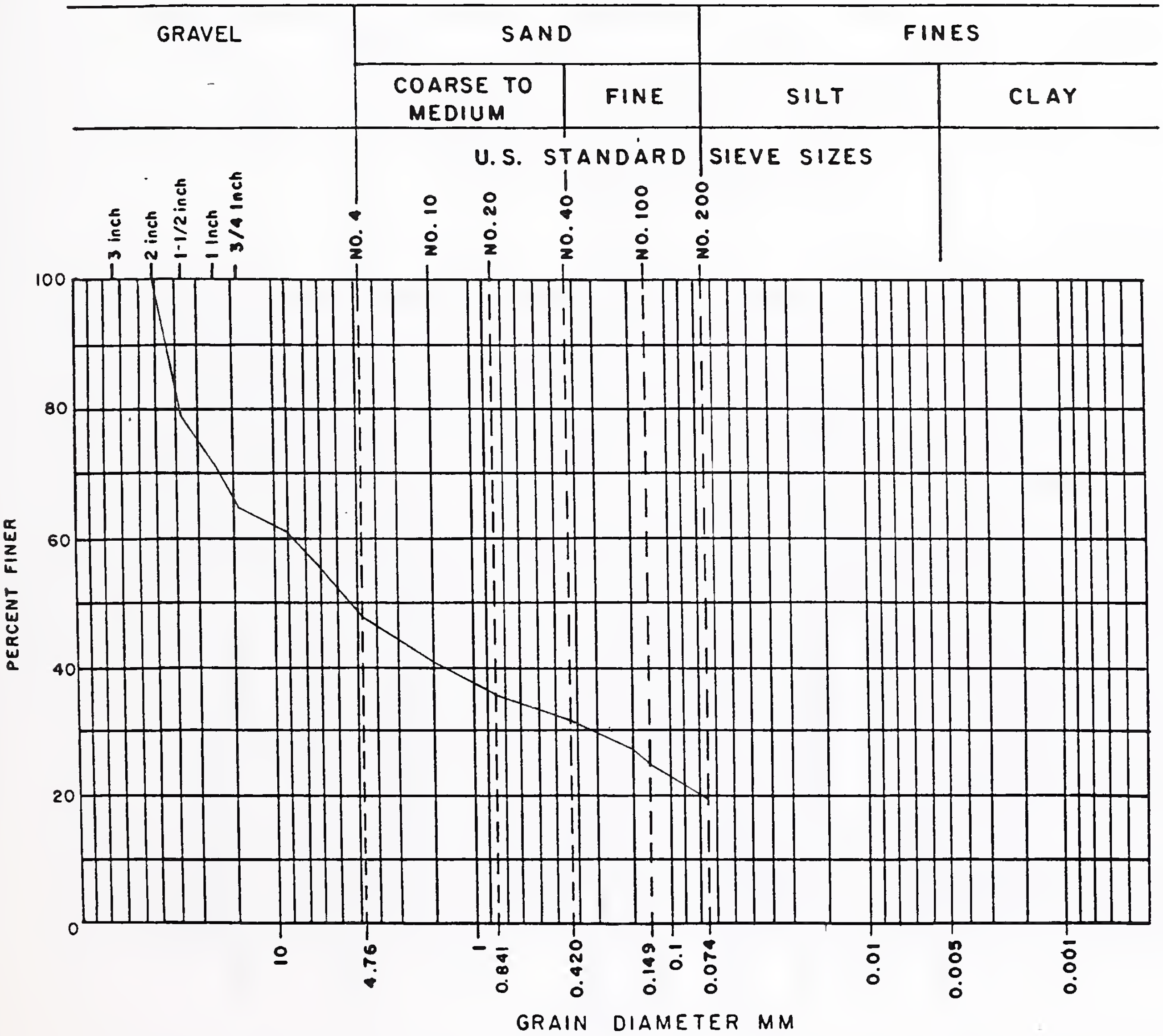
Plate No. 3

FORM ST-5-80
2916

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 2916
PROJECT NAME Middle Creek Dam
FIELD NO. DH-6 (45.0 - 47.1)
DATE SAMPLED 8-4-83
DATE TESTED 10-13-83
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Drive
SAMPLE LOCATION Semi-pervious Zone
SOIL DESCRIPTION SILTY GRAVEL (GM)



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve	52 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve.	29 %
3)_ SILT & CLAY, Passing no. 200 sieve	19 %

Liquid Limit = 28%
Plastic Index = 3

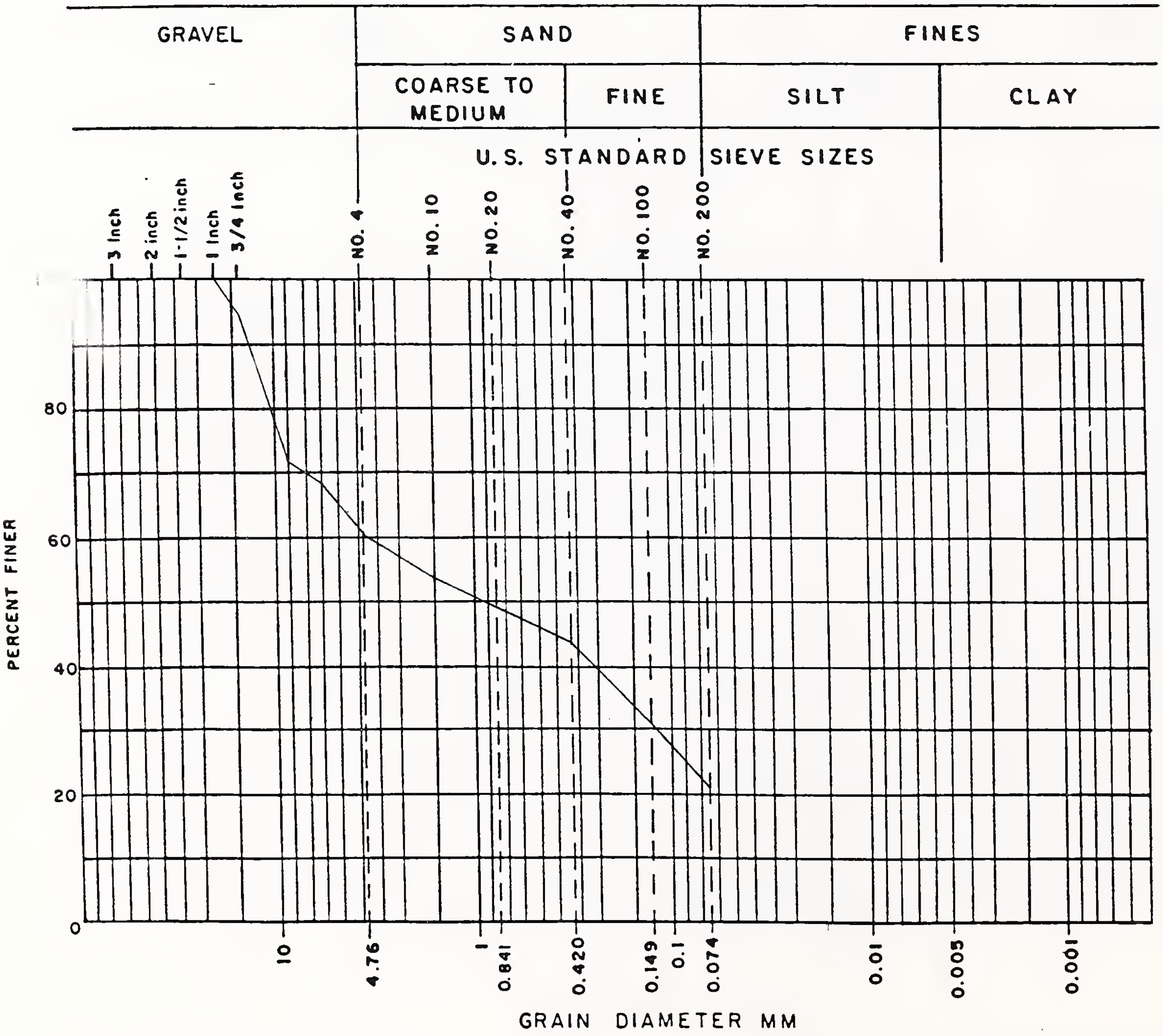
Plate No. 4

FORM ST-5-80
2918

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 2918
PROJECT NAME Middle Creek Dam
FIELD NO. DH-6 (65.0-66.5')
DATE SAMPLED 8-3-83
DATE TESTED 10-13-83
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Drive
SAMPLE LOCATION Semi-pervious Zone
SOIL DESCRIPTION CLAYEY SAND (SC)



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve — 39 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. — 40 %
3)_ SILT & CLAY, Passing no. 200 sieve — 21 %

Liquid Limit = 41%
Plastic Index = 15

Plate No. 5

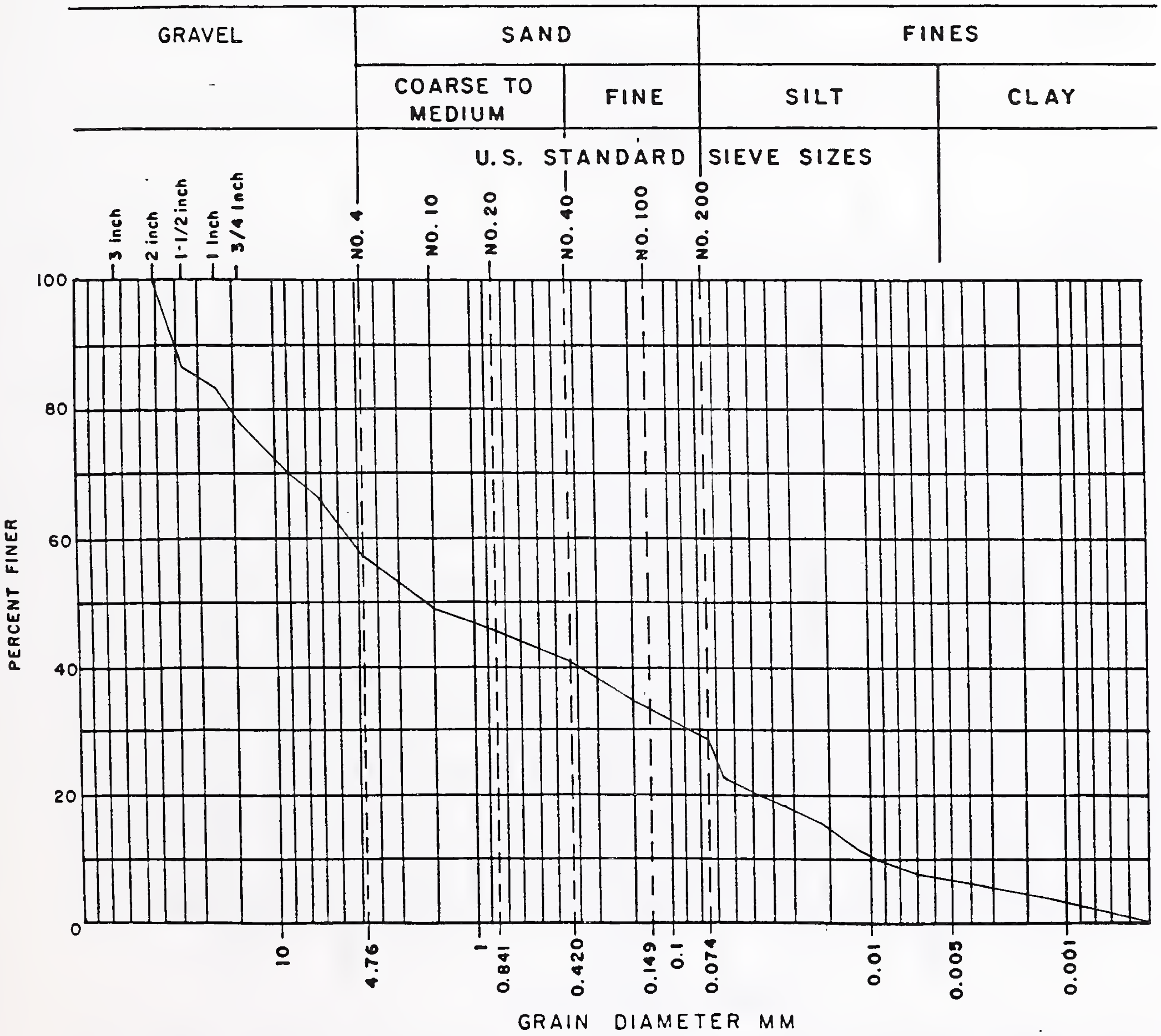
FORM ST-5-80

3010, 11 & 12

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 3010
PROJECT NAME Middle Creek Dam
FIELD NO. DH-7 (12.0-12.5')
DATE SAMPLED 9-28-83
DATE TESTED 10-21-83
SAMPLED BY DLD
TESTED BY JP
TYPE SAMPLE Drive
SAMPLE LOCATION Impervious Zone
SOIL DESCRIPTION CLAYEY GRAVEL (GC)



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve 43 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 28 %
3)_ SILT & CLAY, Passing no. 200 sieve 29 %

Liquid Limit = 33%
Plastic Index = 18

Plate No. 6

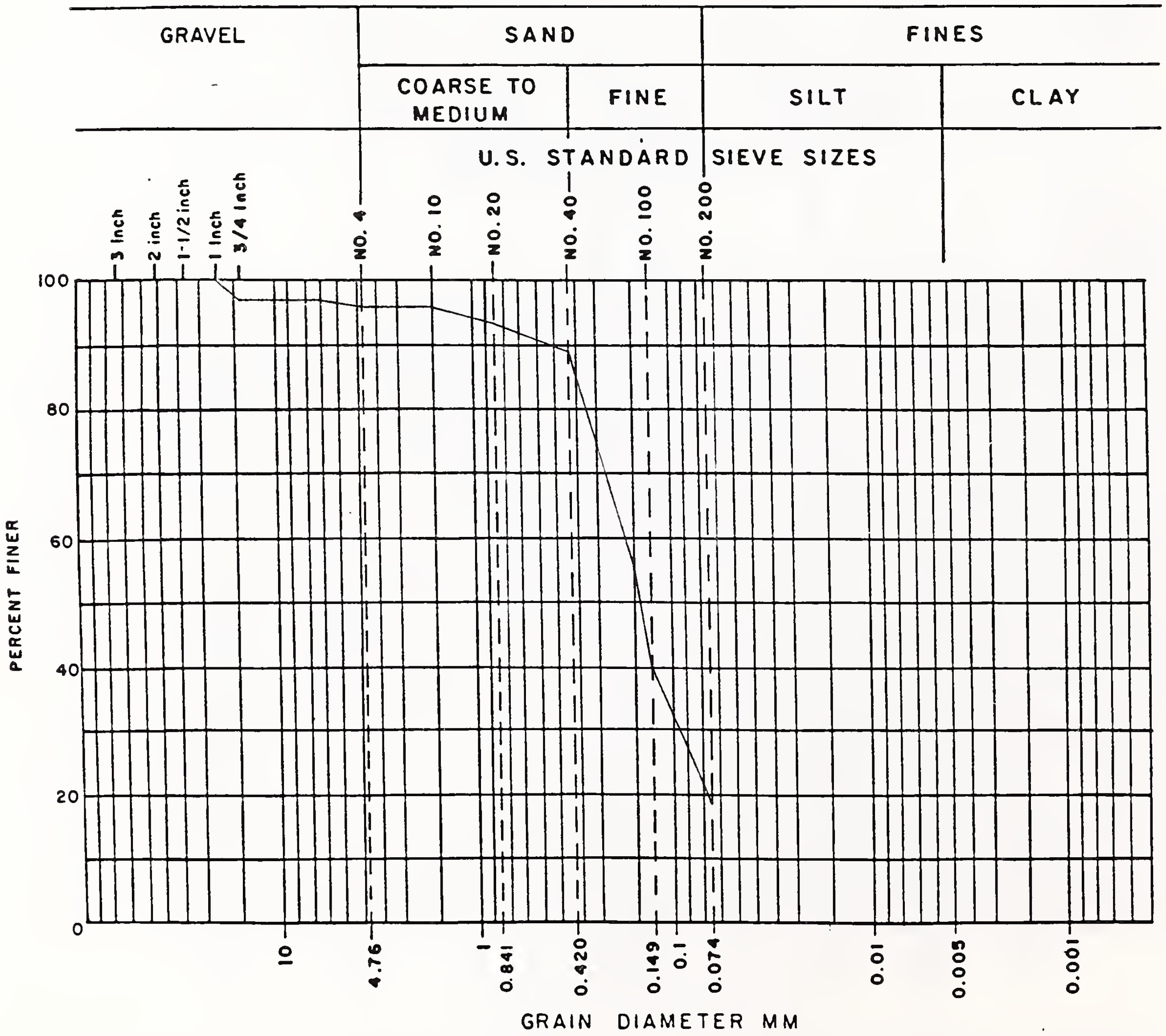
FORM ST-5-80

3019

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO.	8M087.113	LAB NO.	3019
PROJECT NAME	Middle Creek Dam	FIELD NO.	DH-7 (75.0-76.5')
DATE SAMPLED	10-6-83	DATE TESTED	10-24-83
SAMPLED BY	DLD	TESTED BY	CS
TYPE SAMPLE	Drive	SAMPLE LOCATION	Natural Sand Deposit under Upstream Face
SOIL DESCRIPTION	CLAYEY SAND		



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve ____4____%

2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. ____77____%

3)_ SILT & CLAY, Passing no. 200 sieve ____19____%

Fine Sand = 70% Passing no. 40 and retained on no. 200

Plate No. 7

FORM ST-5-80
3020

HKM ASSOCIATES
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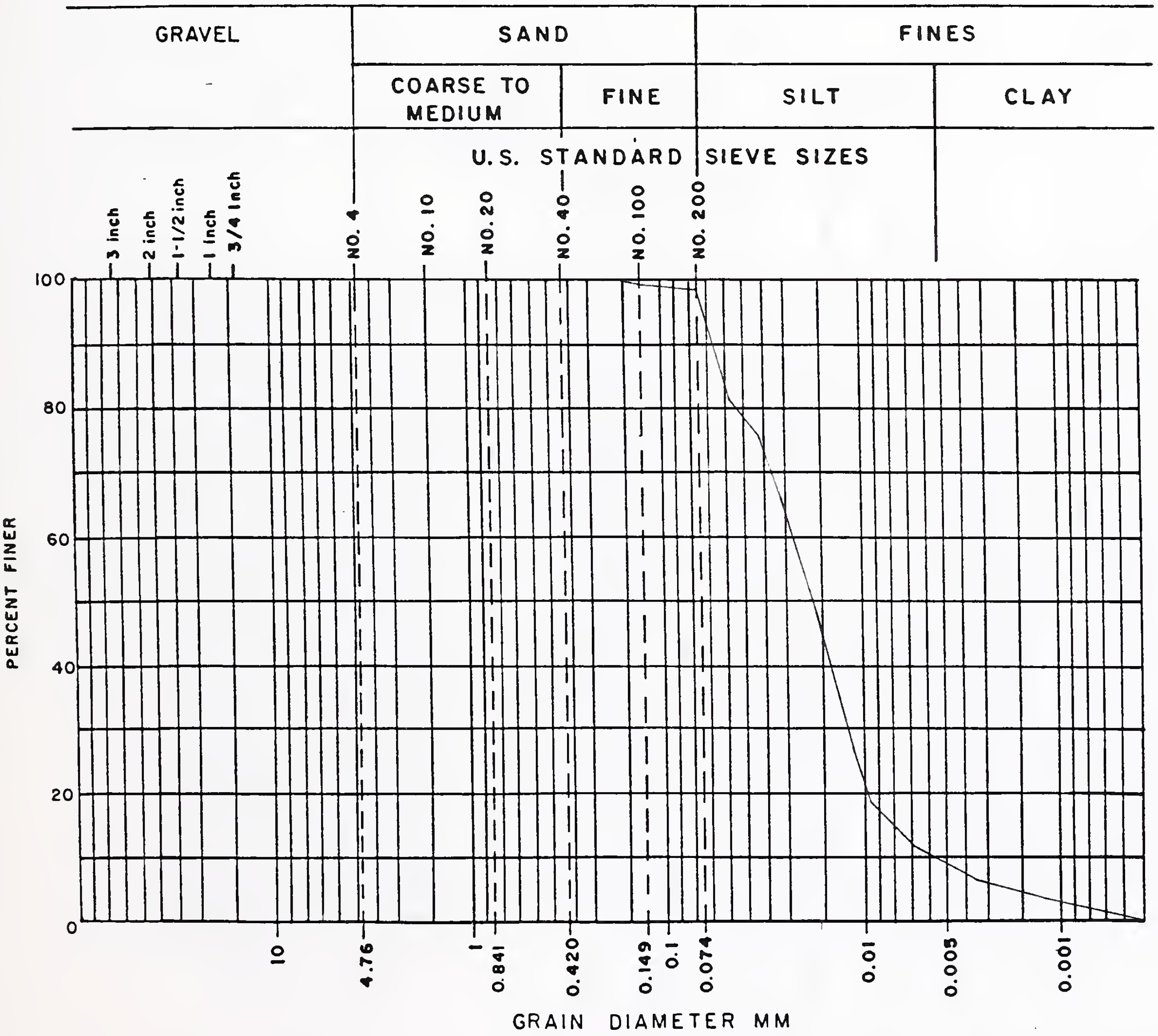
GRAIN SIZE DISTRIBUTION

PROJECT NO.	8M087.113	LAB NO.	3020
PROJECT NAME	Middle Creek Dam	FIELD NO.	DH-7 (82.0-83.5')
DATE SAMPLED	10-7-83	DATE TESTED	10-25-83
SAMPLED BY	DLD	TESTED BY	JP
TYPE SAMPLE	Drive	SAMPLE LOCATION	Foundation Soil Under Upstream Slope
SOIL DESCRIPTION	CLAYEY SILT		



1)– GRAVEL, Passing 3" & retained on no. 4 sieve ______0 %
2)– SAND, Passing no. 4 sieve & retained on no. 200 sieve. ______2 %
3)– SILT & CLAY, Passing no. 200 sieve ______98 %

Granular Non-plastic

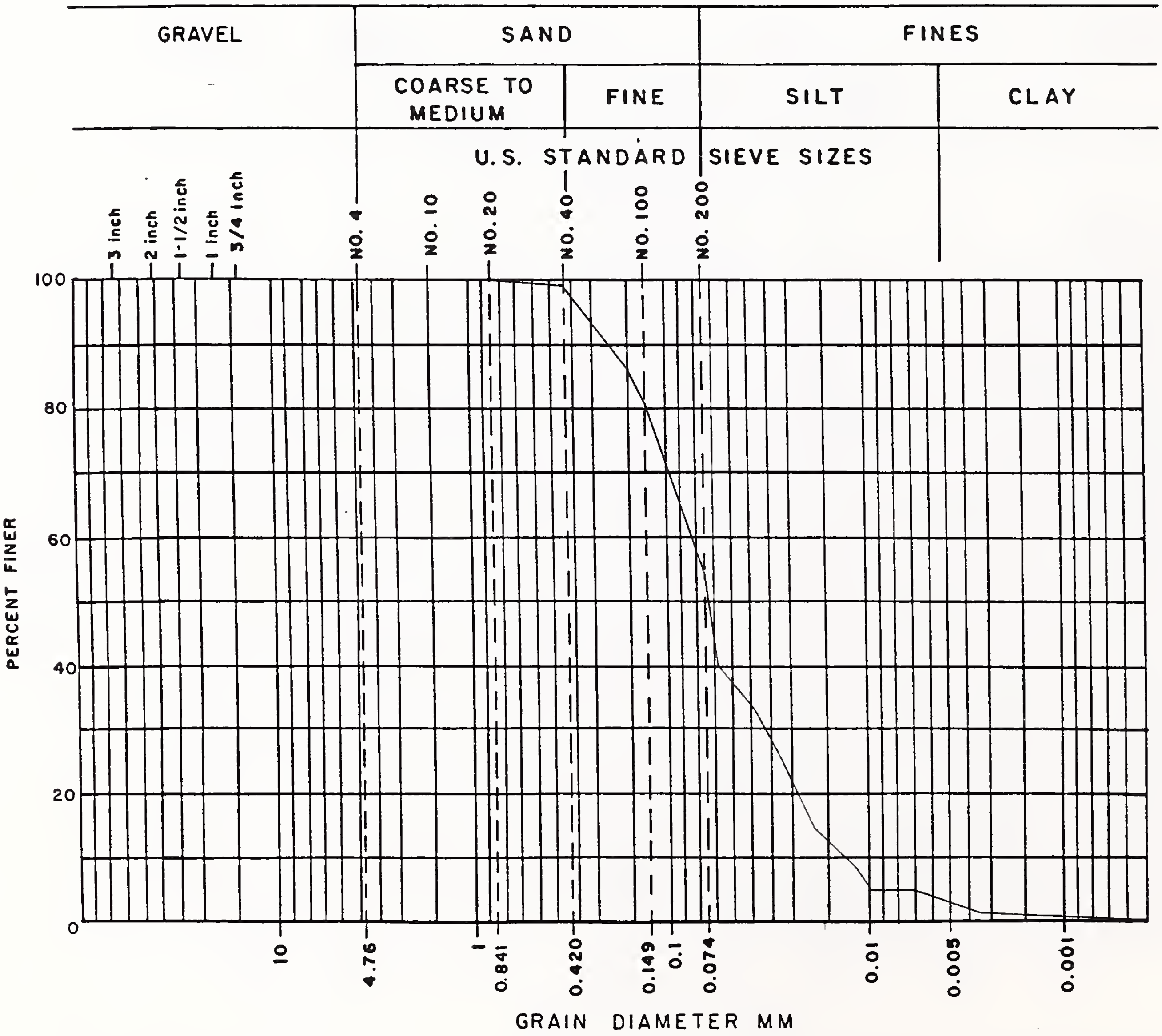
Plate No. 8

FORM ST-5-80
3049

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 3049
PROJECT NAME Middle Creek Dam
FIELD NO. DH-13 (57.0-67.0')
DATE SAMPLED 10-12-83
DATE TESTED 10-21-83
SAMPLED BY DLD
TESTED BY JP
TYPE SAMPLE Sack (cuttings)
SAMPLE LOCATION Right Abutment Foundation Area
SOIL DESCRIPTION SANDY SILT



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve 0 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 46 %
3)_ SILT & CLAY, Passing no. 200 sieve 54 %

Plate No. 9

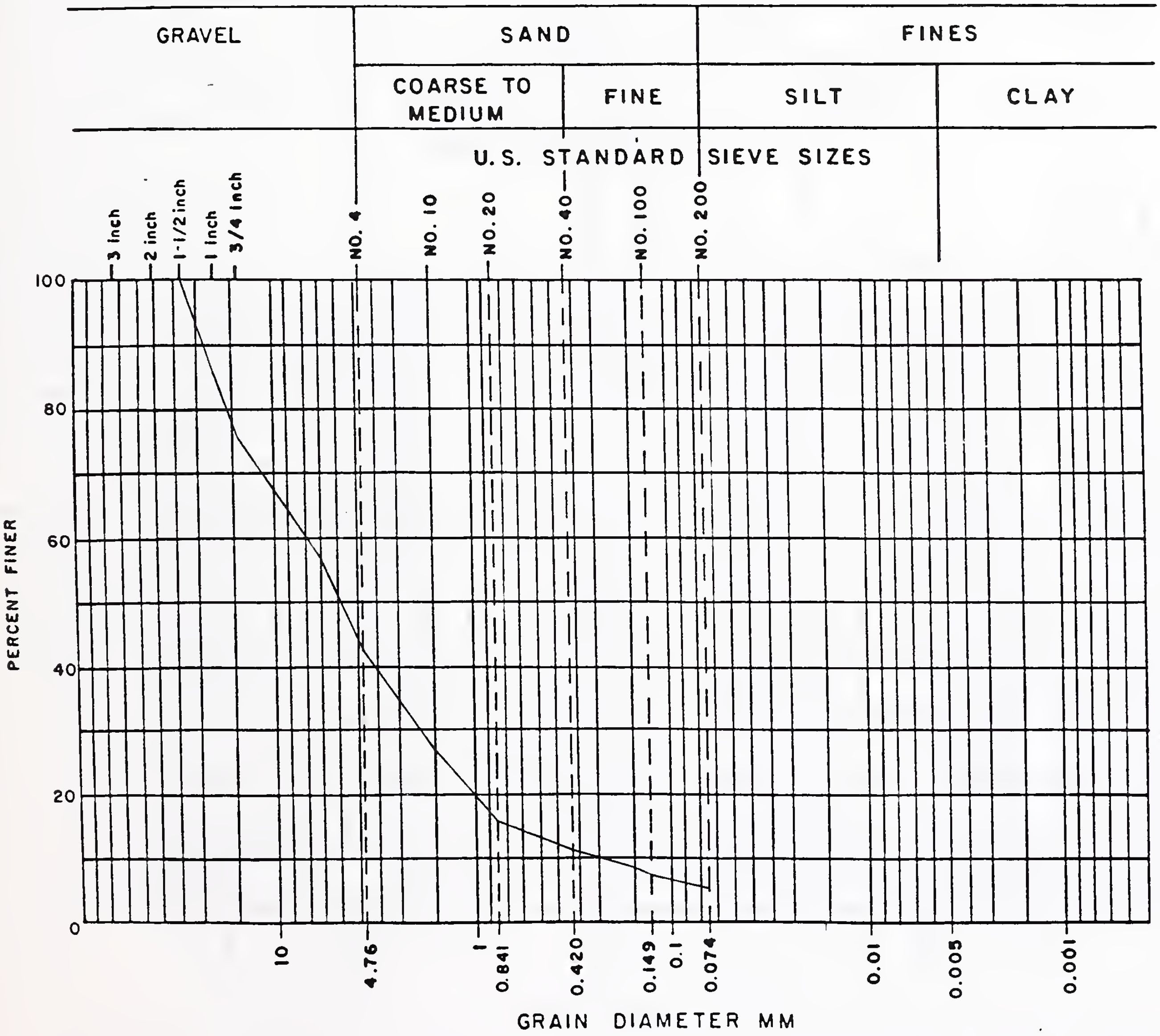
FORM ST-5-80

2926

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 2926
PROJECT NAME Middle Creek Dam
FIELD NO. DH-8 (24.0-25.5')
DATE SAMPLED 7-26-83
DATE TESTED October 1983
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Drive
SAMPLE LOCATION Left Abutment
SOIL DESCRIPTION SANDY GRAVEL TILL



1)- GRAVEL, Passing 3" & retained on no. 4 sieve 57 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve. 38 %
3)- SILT & CLAY, Passing no. 200 sieve 5 %

Plate No. 10

FORM ST-5-80

2944

HKM ASSOCIATES
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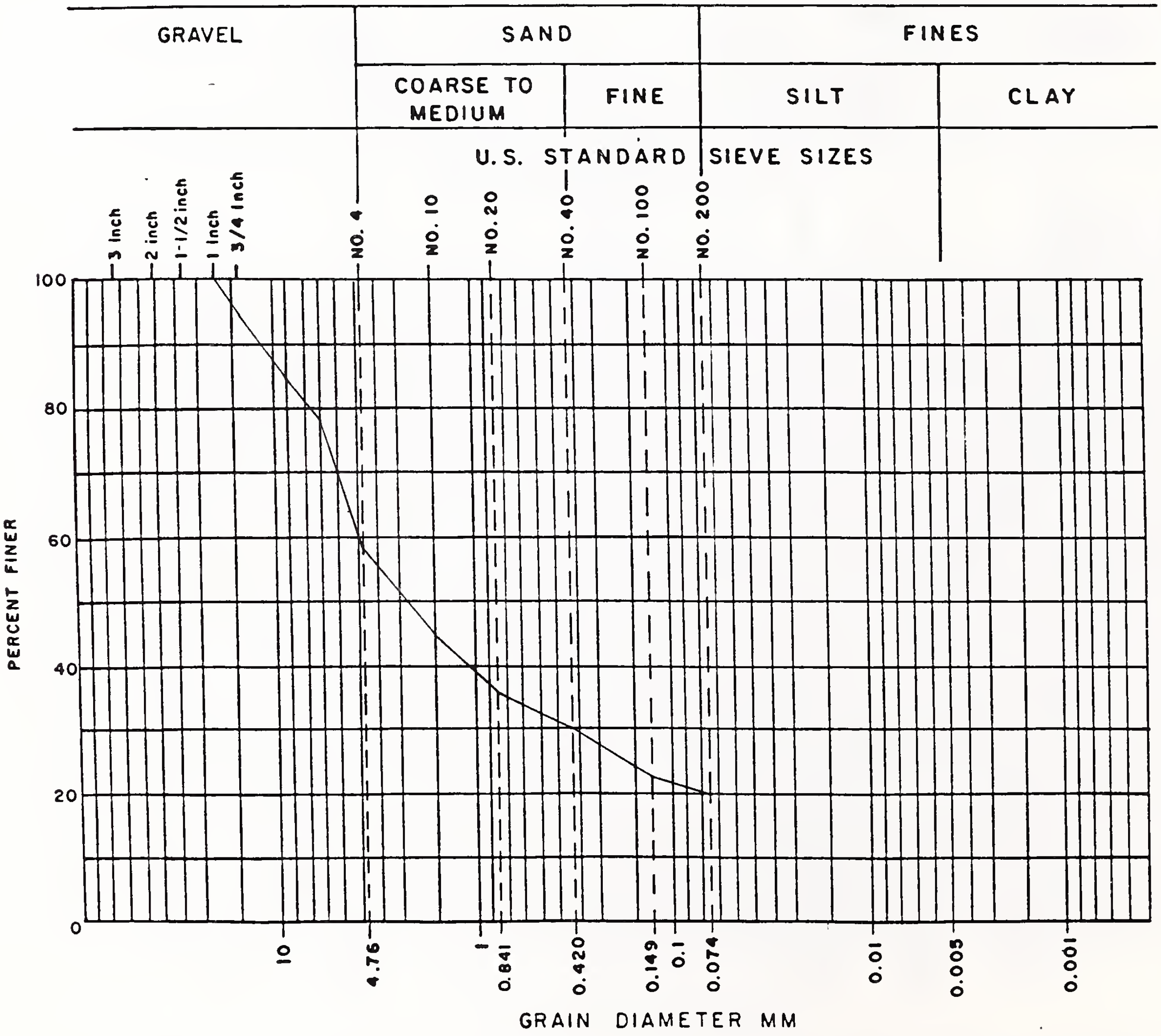
GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
PROJECT NAME Middle Creek Dam
DATE SAMPLED 7-22-83
SAMPLED BY DLD
TYPE SAMPLE Drive
SOIL DESCRIPTION CLAYEY GRAVEL FILL

LAB NO. 2944
FIELD NO. DH-10 (10.0-11.5')
DATE TESTED 10-8-83
TESTED BY CS
SAMPLE LOCATION Left Abutment



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve	41 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve.	39 %
3)_ SILT & CLAY, Passing no. 200 sieve	20 %

Plate No. 11

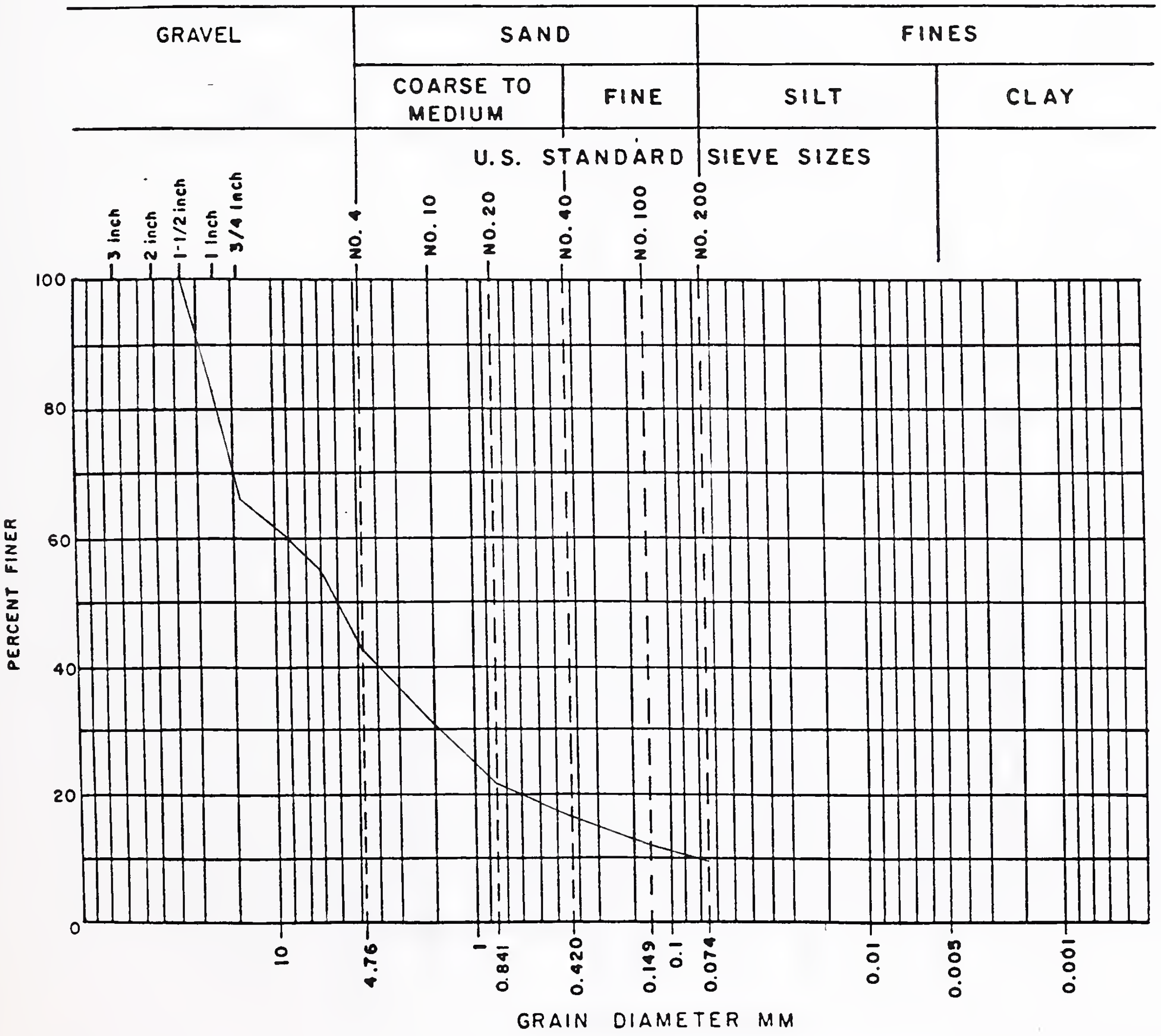
FORM ST-5-80

3039

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 3039
PROJECT NAME Middle Creek Dam
FIELD NO. DH-12 (8.0-9.5')
DATE SAMPLED 10-12-83
DATE TESTED 11-2-83
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Drive
SAMPLE LOCATION Potential Auxiliary Spillway Area
SOIL DESCRIPTION SANDY GRAVEL TILL



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve 57 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 33 %
3)_ SILT & CLAY, Passing no. 200 sieve 10 %

Plate No. 12

FORM ST-5-80

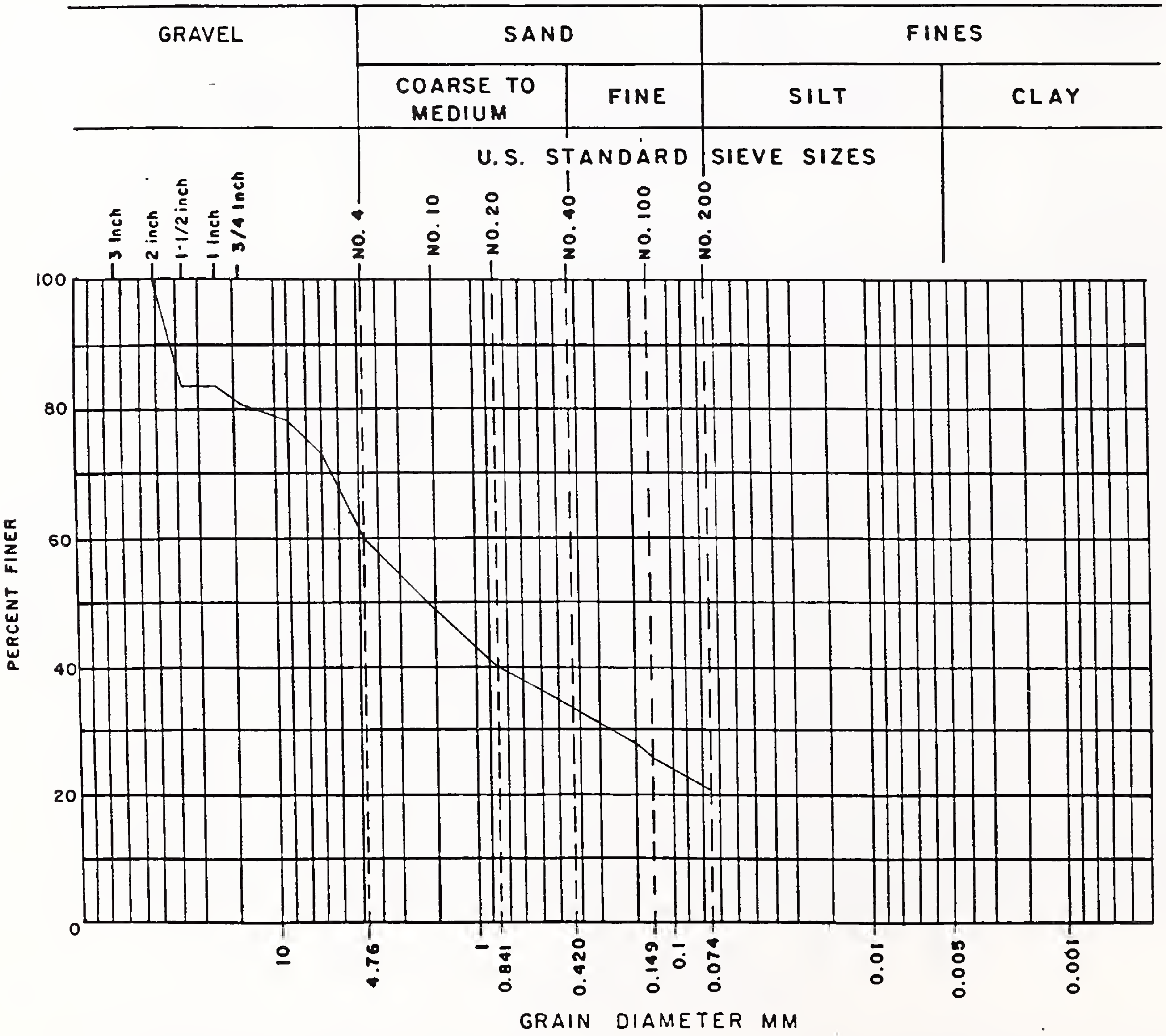
3044

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
PROJECT NAME Middle Creek Dam
DATE SAMPLED 10-10-83
SAMPLED BY DLD
TYPE SAMPLE Drive
SOIL DESCRIPTION CLAYEY GRAVEL FILL

LAB NO. 3044
FIELD NO. DH-13 (27.0-29.0')
DATE TESTED 11-2-83
TESTED BY CS
SAMPLE LOCATION Upstream Face- Impervious Zone



1)- GRAVEL, Passing 3" & retained on no. 4 sieve 40 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve. 39 %
3)- SILT & CLAY, Passing no. 200 sieve 21 %

Plate No. 13

FORM ST-5-80

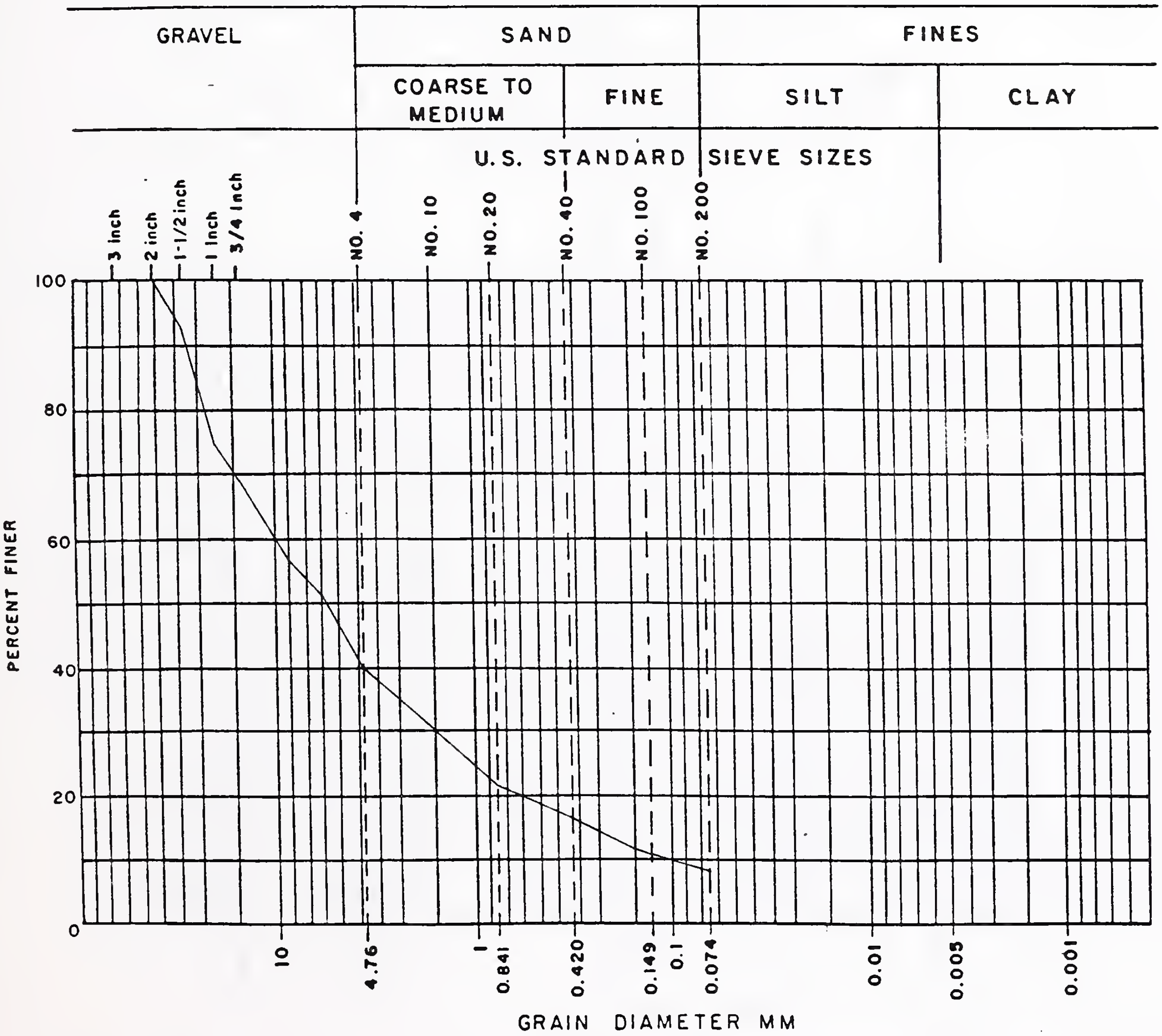
2956 # 57

HKM ASSOCIATES

ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO.	8M087.113	LAB NO.	2956
PROJECT NAME	Middle Creek Dam	FIELD NO.	DH-14 (6.0-7.5')
DATE SAMPLED	8-14-83	DATE TESTED	10-13-83
SAMPLED BY	DLD	TESTED BY	CS
TYPE SAMPLE	Drive	SAMPLE LOCATION	Pervious Zone
SOIL DESCRIPTION	SANDY GRAVEL FILL		Near Right Abutment



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve ——— 60 —— %

2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. ——— 32 —— %

3)_ SILT & CLAY, Passing no. 200 sieve ——— 8 —— %

Plate No. 14

FORM ST-5-80

2960

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113

LAB NO. 2960

PROJECT NAME Middle Creek Dam

FIELD NO. DH-14 (36.0-37.5)

DATE SAMPLED 8-15-83

DATE TESTED 9-23-83

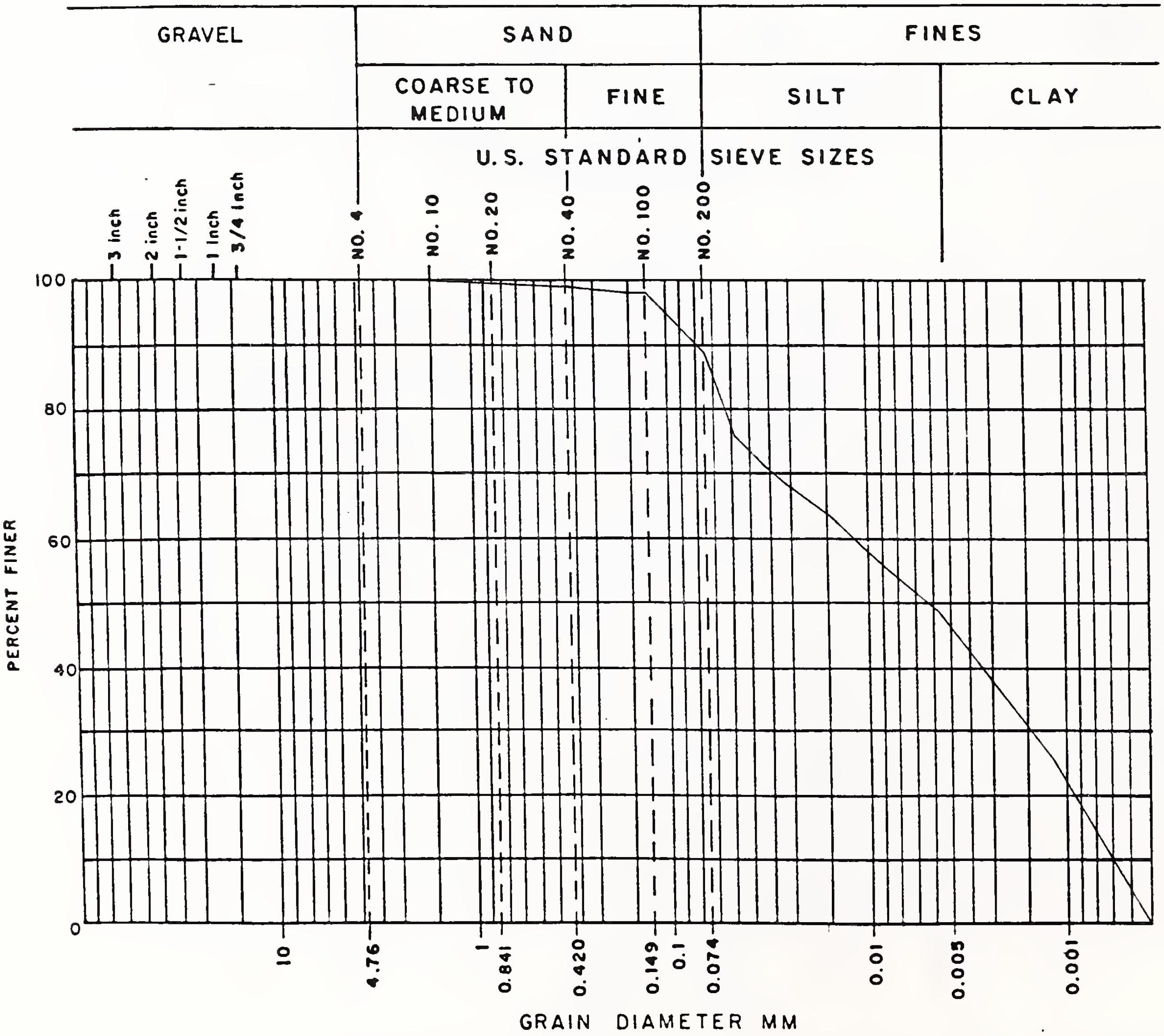
SAMPLED BY DLD

TESTED BY CS

TYPE SAMPLE Drive

SAMPLE LOCATION Right Abutment

SOIL DESCRIPTION SILTY CLAY (CL-2)



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve 0 %

2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 11 %

3)_ SILT & CLAY, Passing no. 200 sieve 89 %

Liquid Limit = 46%
Plastic Index = 28

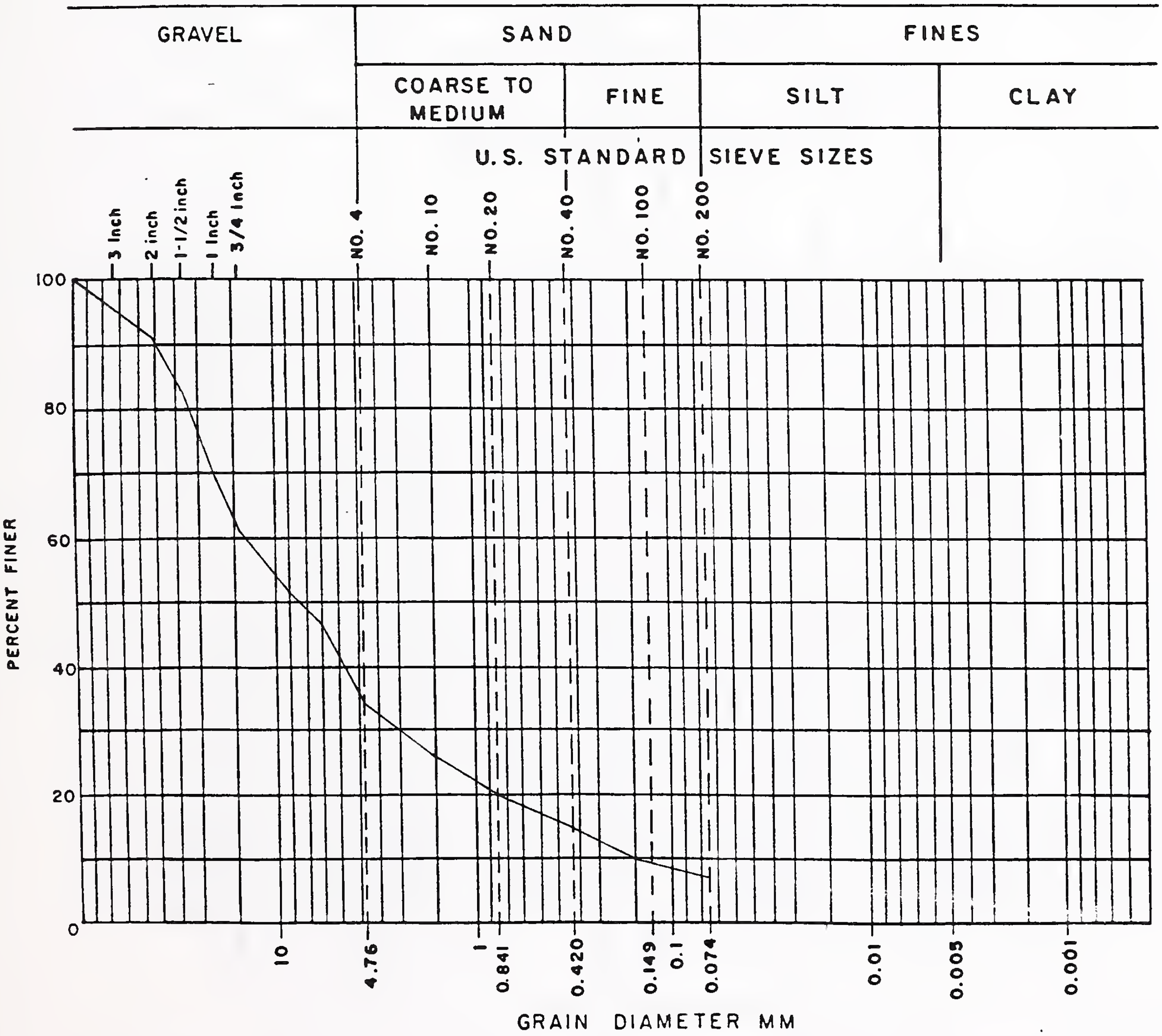
Plate No. 15

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

FORM ST-5-80
3052

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 3052
PROJECT NAME Middle Creek Dam
FIELD NO. TP-102 (1.0-4.0')
DATE SAMPLED 10-19-83
DATE TESTED 10-24-83
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Sack
SAMPLE LOCATION Pervious Zone Near Right Abutment
SOIL DESCRIPTION SANDY GRAVEL FILL



1)_ GRAVEL, Passing 4" & retained on no. 4 sieve 65 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 28 %
3)_ SILT & CLAY, Passing no. 200 sieve 7 %

Maximum Size = 4"

Plate No. 16

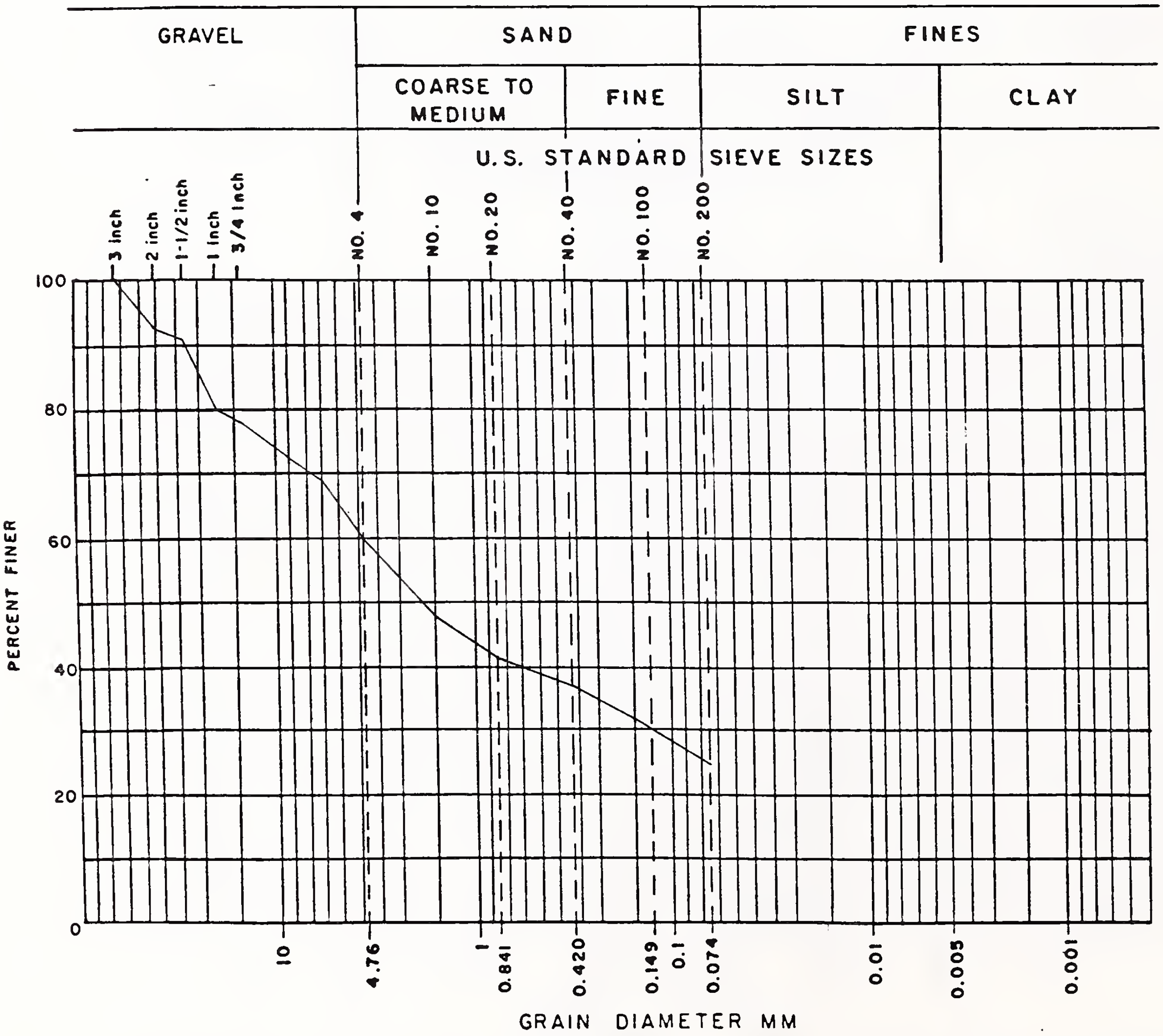
FORM ST-5-80

3053

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 3053
PROJECT NAME Middle Creek Dam
FIELD NO. TP-103 (4.0-7.0')
DATE SAMPLED 10-12-83
DATE TESTED 10-24-83
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Sack
SAMPLE LOCATION Right Abutment On Upstream Face
SOIL DESCRIPTION CLAYEY GRAVEL (GC)



1)- GRAVEL, Passing 3" & retained on no. 4 sieve 40 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve. 35 %
3)- SILT & CLAY, Passing no. 200 sieve 25 %

Liquid Limit = 36%
Plastic Index = 17

Plate No. 17

FORM ST-5-80

3026

HKM ASSOCIATES
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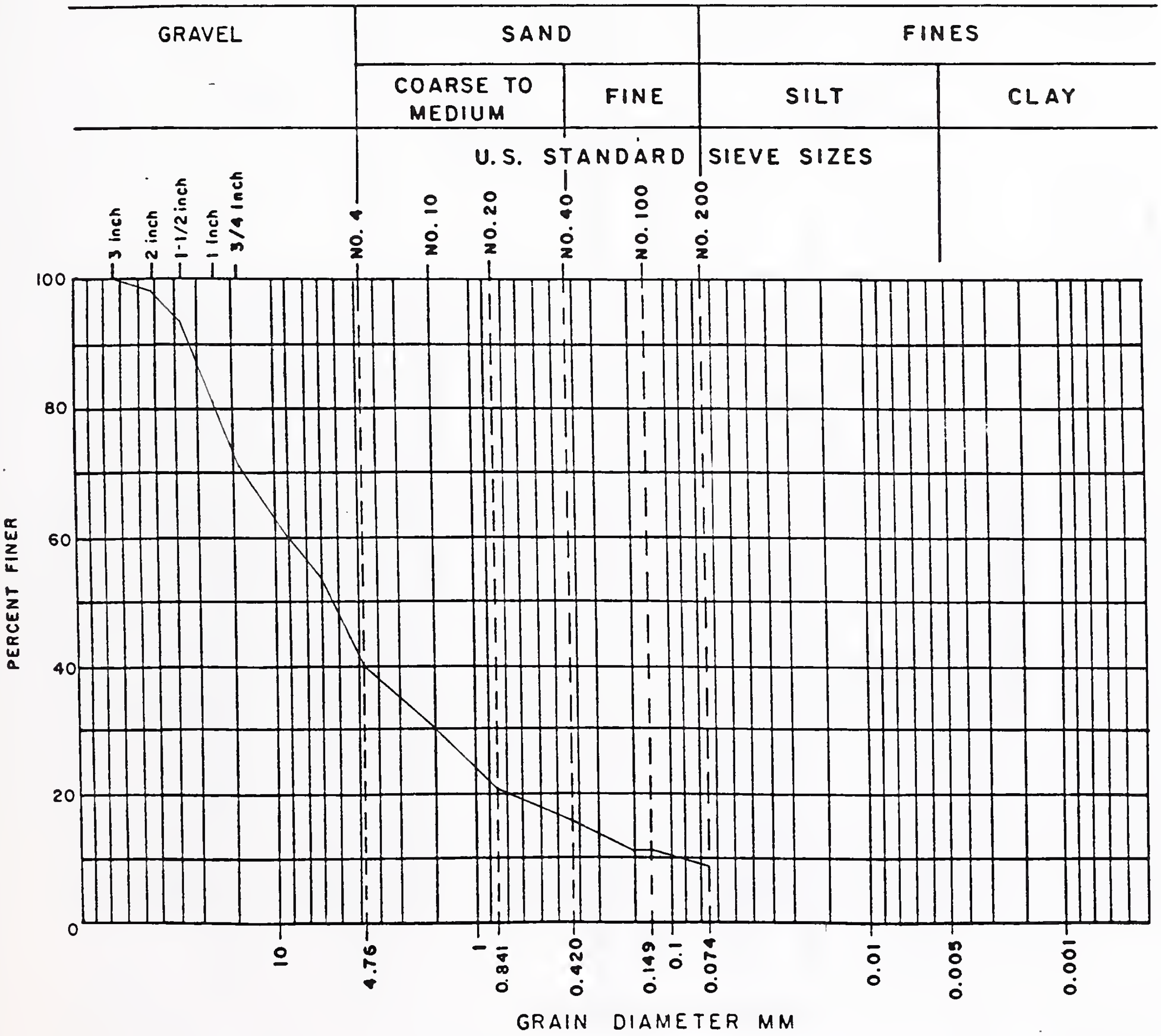
GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 3026
PROJECT NAME Middle Creek Dam
FIELD NO. TP-104 (3.7 - 10.0')
DATE SAMPLED 10-12-83
DATE TESTED 11-2-83
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Sack
SAMPLE LOCATION Sink Hole Area
SOIL DESCRIPTION SANDY GRAVEL TILL



1)- GRAVEL, Passing 3" & retained on no. 4 sieve 60 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve. 31 %
3)- SILT & CLAY, Passing no. 200 sieve 9 %

Plate No. 18

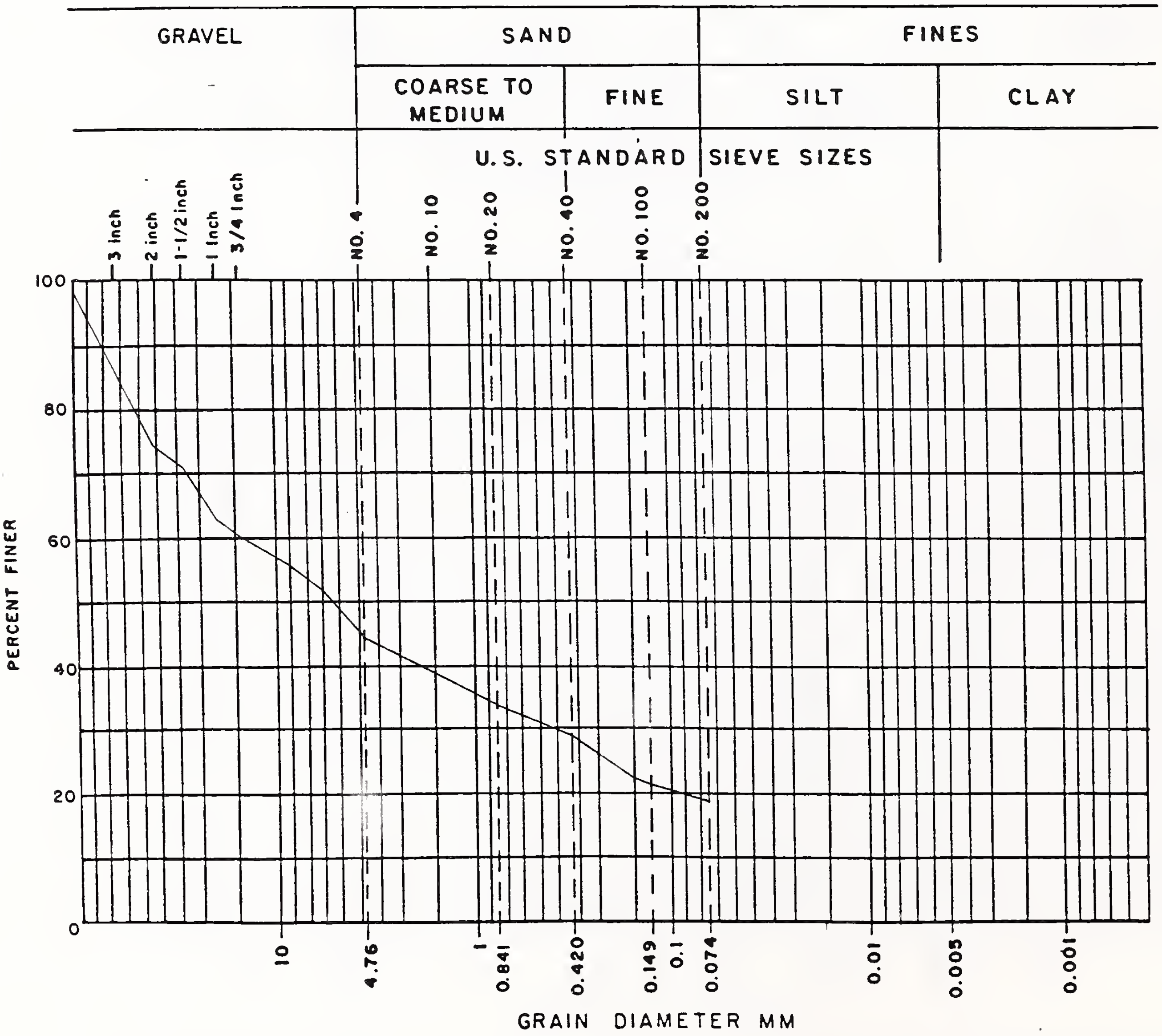
FORM ST-5-80

3054

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 3054
PROJECT NAME Middle Creek Dam
FIELD NO. TP-105 (1.0-8.0')
DATE SAMPLED 10-19-83
DATE TESTED 11-2-83
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Sack
SAMPLE LOCATION Potential Auxiliary Spillway Area
SOIL DESCRIPTION CLAYEY GRAVEL (GC)



1)- GRAVEL, Passing 6" & retained on no. 4 sieve 55 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve. 26 %
3)- SILT & CLAY, Passing no. 200 sieve 19 %

Maximum Size = 6"
Liquid Limit = 30%
Plastic Index = 9

Plate No. 19

FORM ST-5-80
3056

HKM ASSOCIATES
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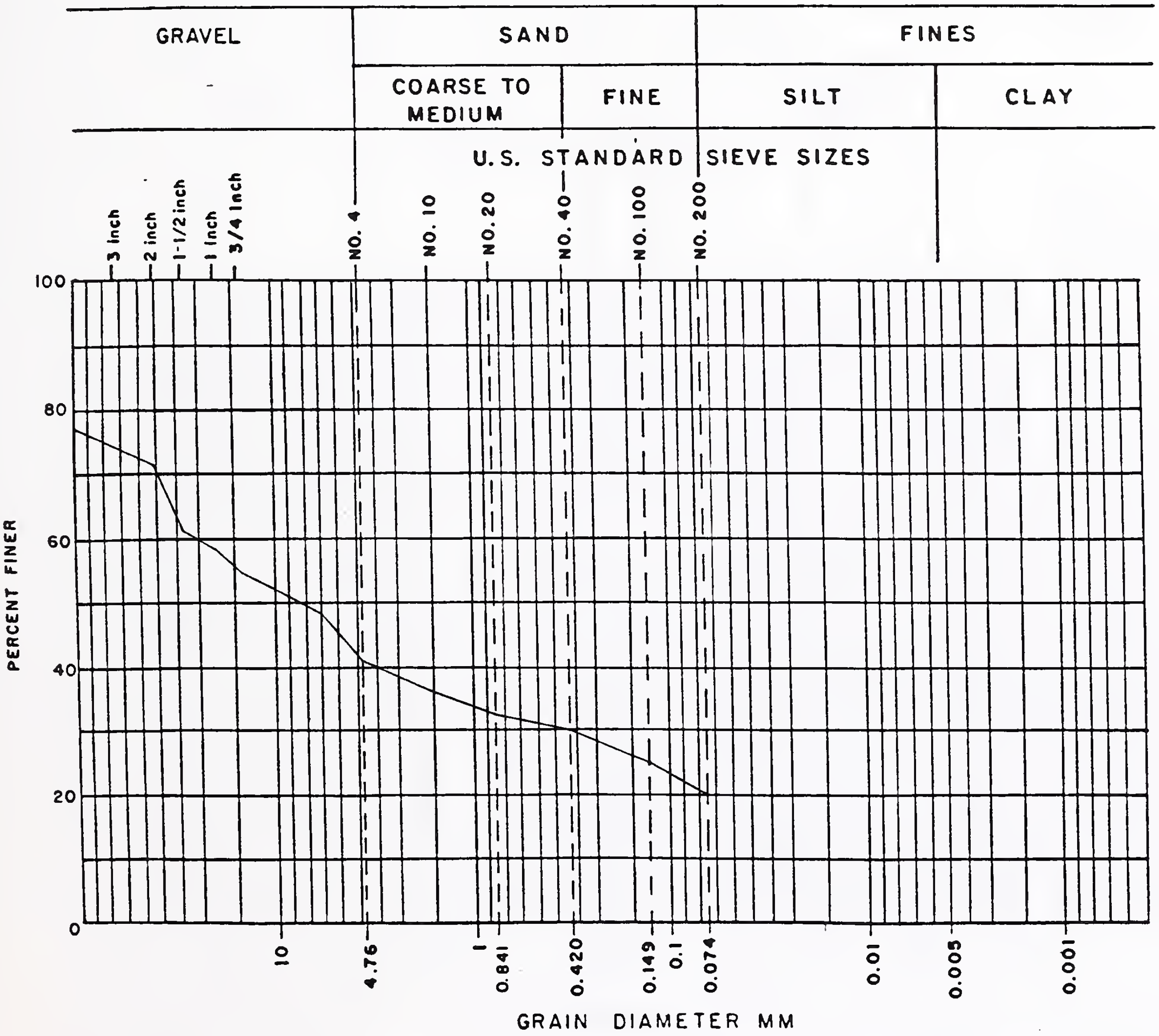
GRAIN SIZE DISTRIBUTION

PROJECT NO.	8M087.113	LAB NO.	3056
PROJECT NAME	Middle Creek Dam	FIELD NO.	TP-106 (3.0-8.0')
DATE SAMPLED	10-19-83	DATE TESTED	10-28-83
SAMPLED BY	DLD	TESTED BY	JP
TYPE SAMPLE	Sack	SAMPLE LOCATION	Potential Auxiliary Spillway Area
SOIL DESCRIPTION	CLAYEY GRAVEL (GC)		



1)_ GRAVEL, Passing 6" & retained on no. 4 sieve 59 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 21 %
3)_ SILT & CLAY, Passing no. 200 sieve 20 %

Maximum Size = 6"

Plate No. 20

FORM ST-5-80

3058

HKM ASSOCIATES
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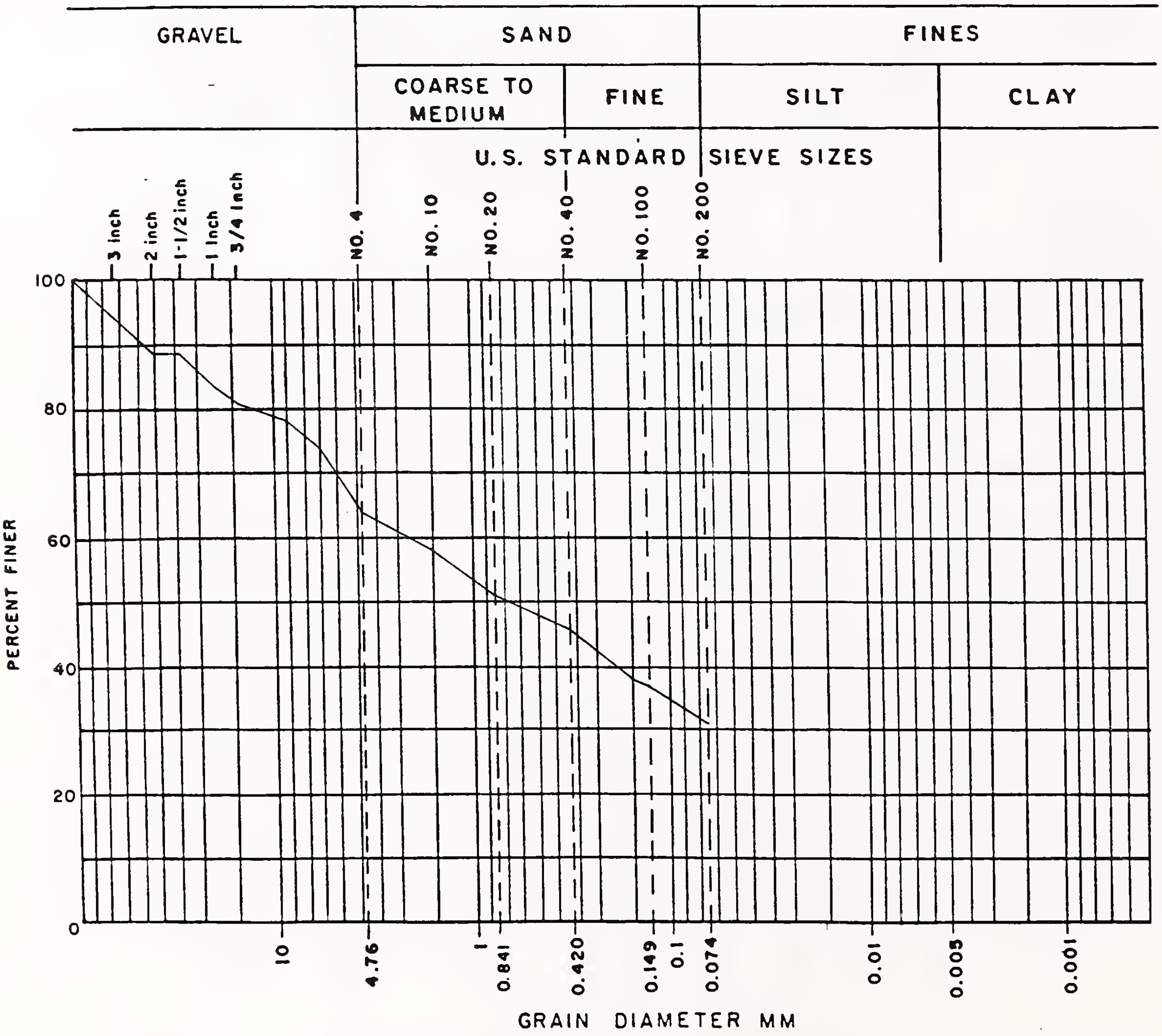
GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
PROJECT NAME Middle Creek Dam
DATE SAMPLED 10-18-83
SAMPLED BY DLD
TYPE SAMPLE Sack
SOIL DESCRIPTION CLAYEY GRAVEL (GC)

LAB NO. 3058
FIELD NO. TP-108 (1.4-6.0')
DATE TESTED 11-2-83
TESTED BY CS
SAMPLE LOCATION Borrow Area
Southeast of Embankment



1)_ GRAVEL, Passing 4" & retained on no. 4 sieve 36 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 33 %
3)_ SILT & CLAY, Passing no. 200 sieve 31 %

Maximum Size = 4"
Liquid Limit = 29%
Plastic Index = 9

Plate No. 21

FORM ST-5-80

3025

HKM ASSOCIATES
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GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113

LAB NO. 3025

PROJECT NAME Middle Creek Dam

FIELD NO. TP-112 (1.2 - 4.0')

DATE SAMPLED 10-12-83

DATE TESTED 10-25-83

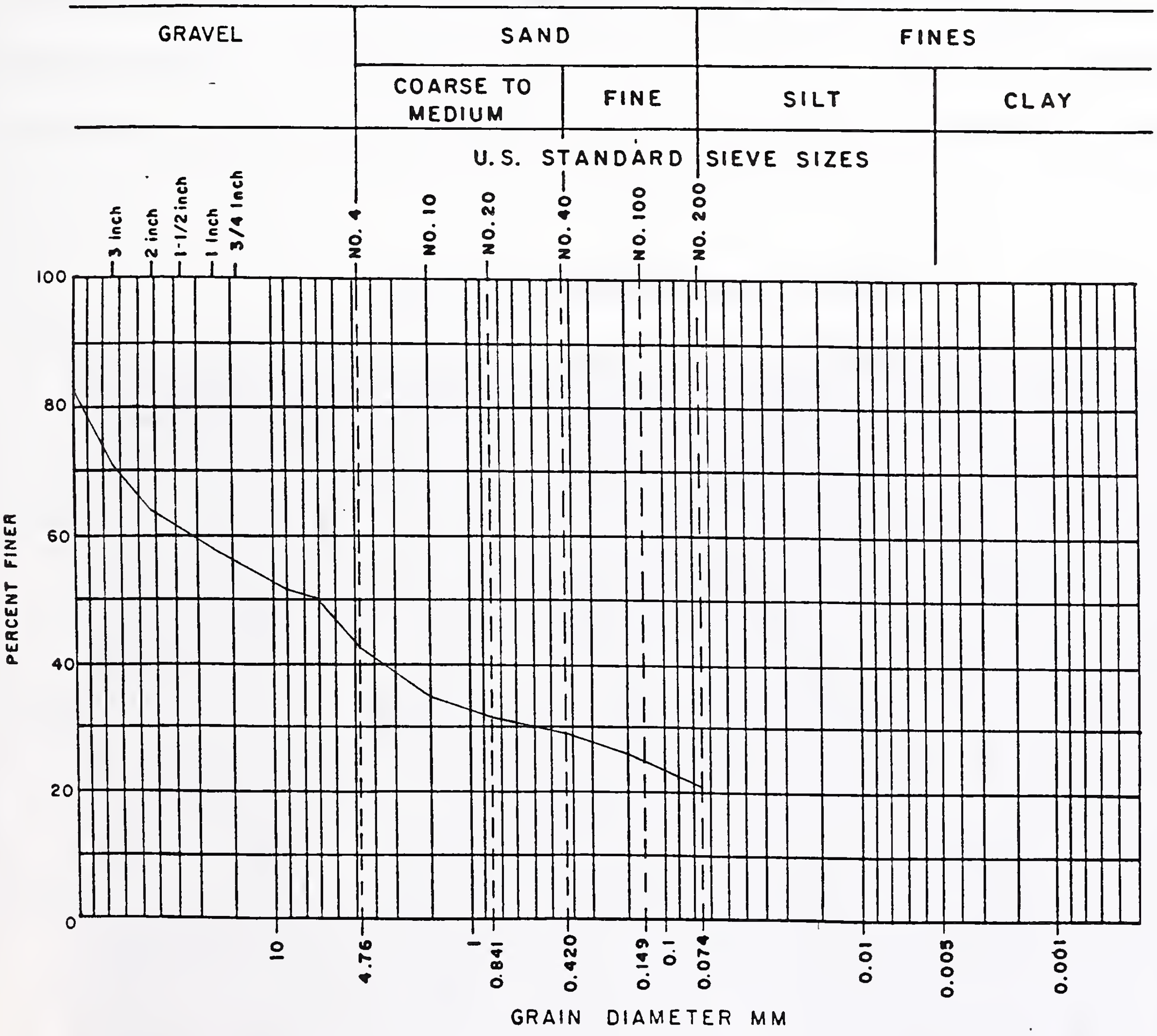
SAMPLED BY DLD

TESTED BY JP

TYPE SAMPLE Sack

SAMPLE LOCATION Borrow Area

SOIL DESCRIPTION CLAYEY GRAVEL (GC)



1)- GRAVEL, Passing 6" & retained on no. 4 sieve	58 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve.	21 %
3)- SILT & CLAY, Passing no. 200 sieve	21 %

Maximum Size = 6"
Liquid Limit = 41%
Plastic Index = 16

Plate No. 22

HKM ASSOCIATES
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MOISTURE DENSITY RELATIONS OF SOILS

3051

Project No. 8M087.113

Project Name Middle Creek Dam

Date Sampled 10-18-83

Soil Class. GRAVELLY CLAY TILL

Maximum Dry Density 114.7 pcf

Optimum Moisture 15.1%

Lab No. 3051 TP-101 (2.0 - 8.0')

Test Designation ASTM 0698

Date Tested 10-31-83

% Passing # 4Sieve -

MOISTURE-DENSITY GRAPH

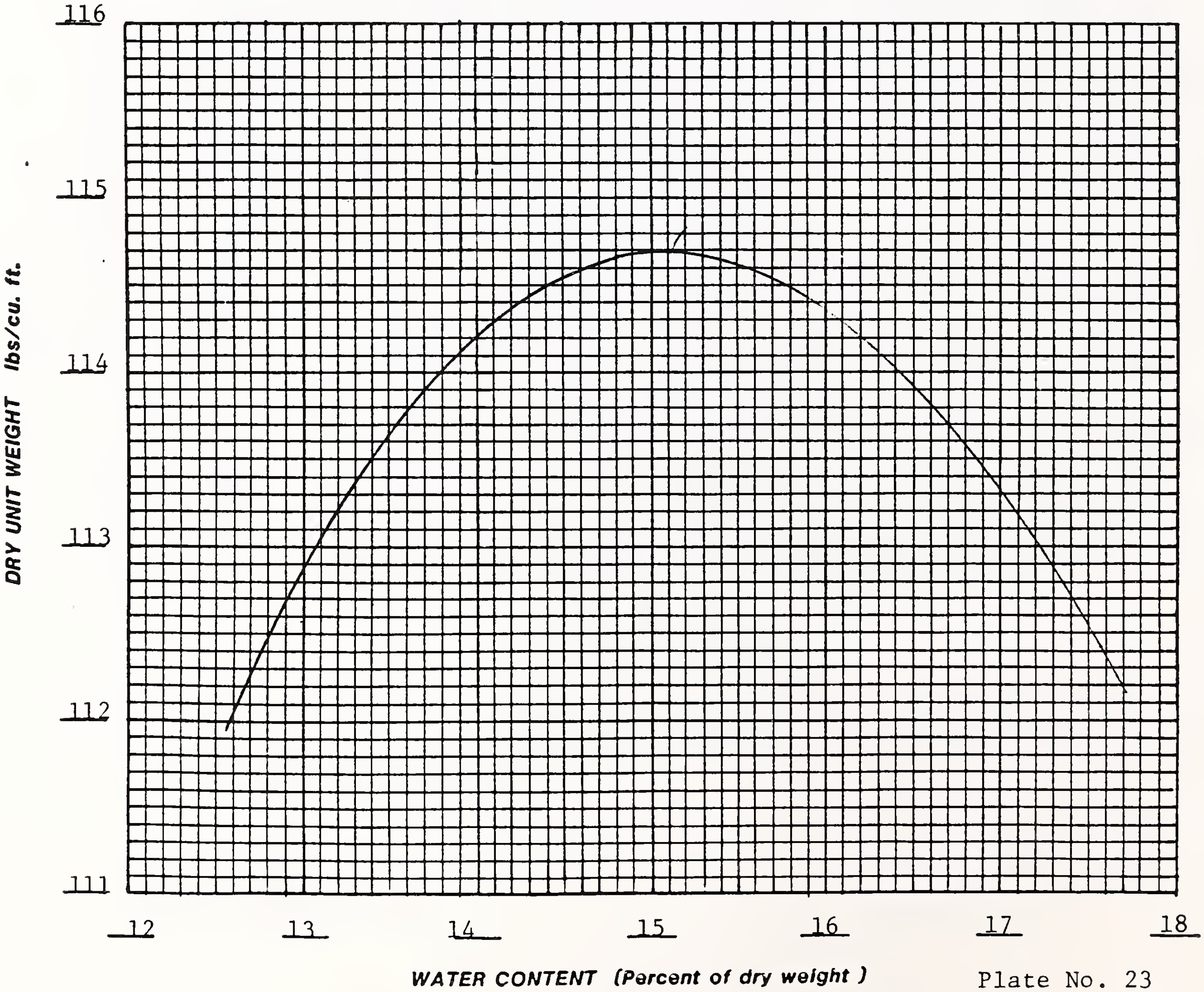

Plate No. 23

KM ASSOCIATES
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MOISTURE DENSITY RELATIONS OF SOILS

3056

Project No. 8M087.113

Project Name Middle Creek Dam

Date Sampled 10-19-83

Soil Class. CLAYEY GRAVEL (GC)

Maximum Dry Density 125.6 pcf

Optimum Moisture 10.3%

Lab No. 3056 TP-106 (3.0-8.0')

Test Designation ASTM D698

Date Tested 11-1-83

% Passing # 4Sieve 41

MOISTURE-DENSITY GRAPH

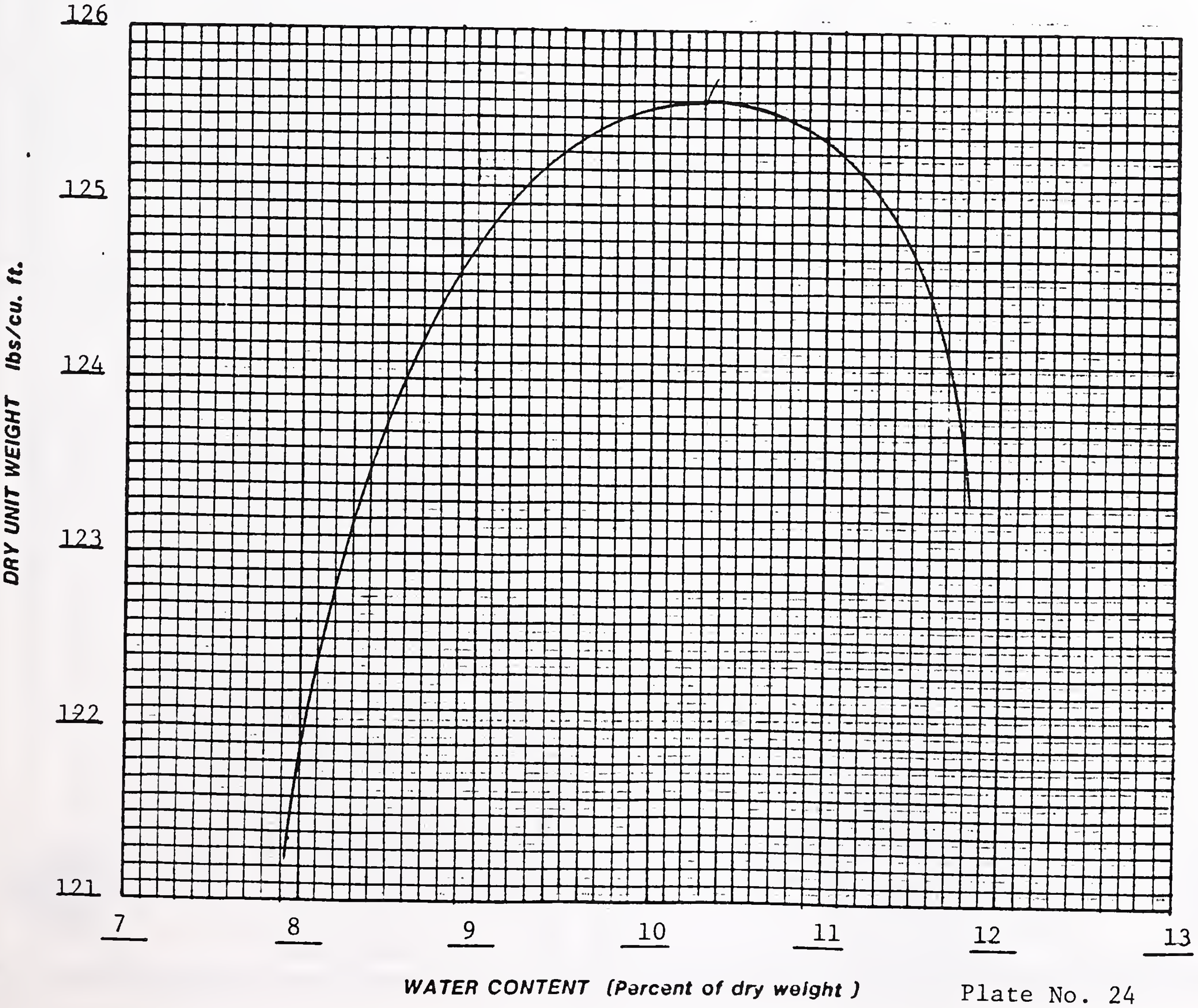
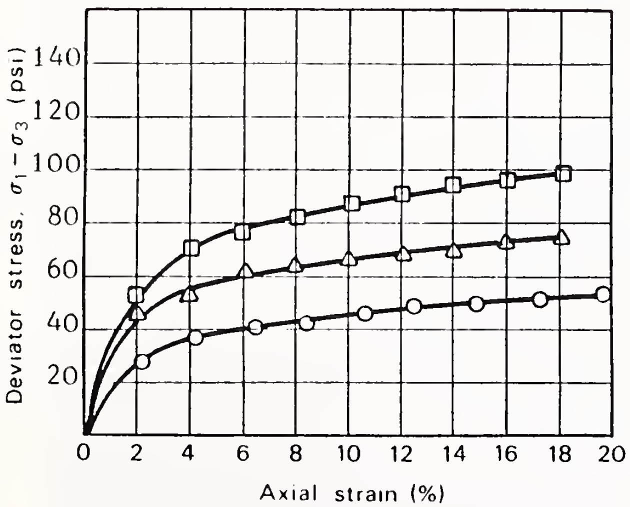
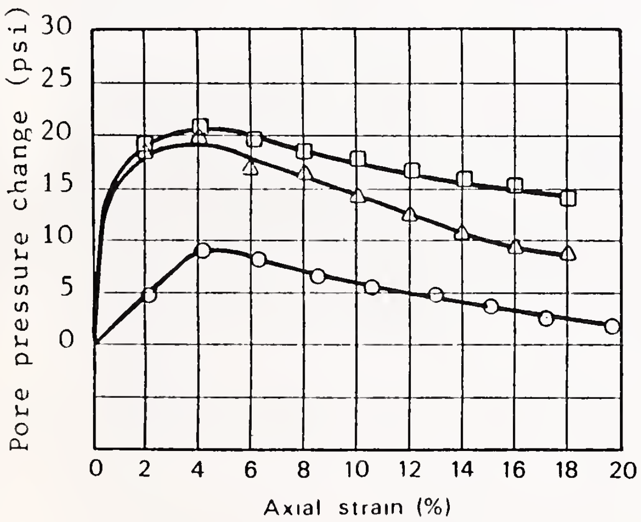
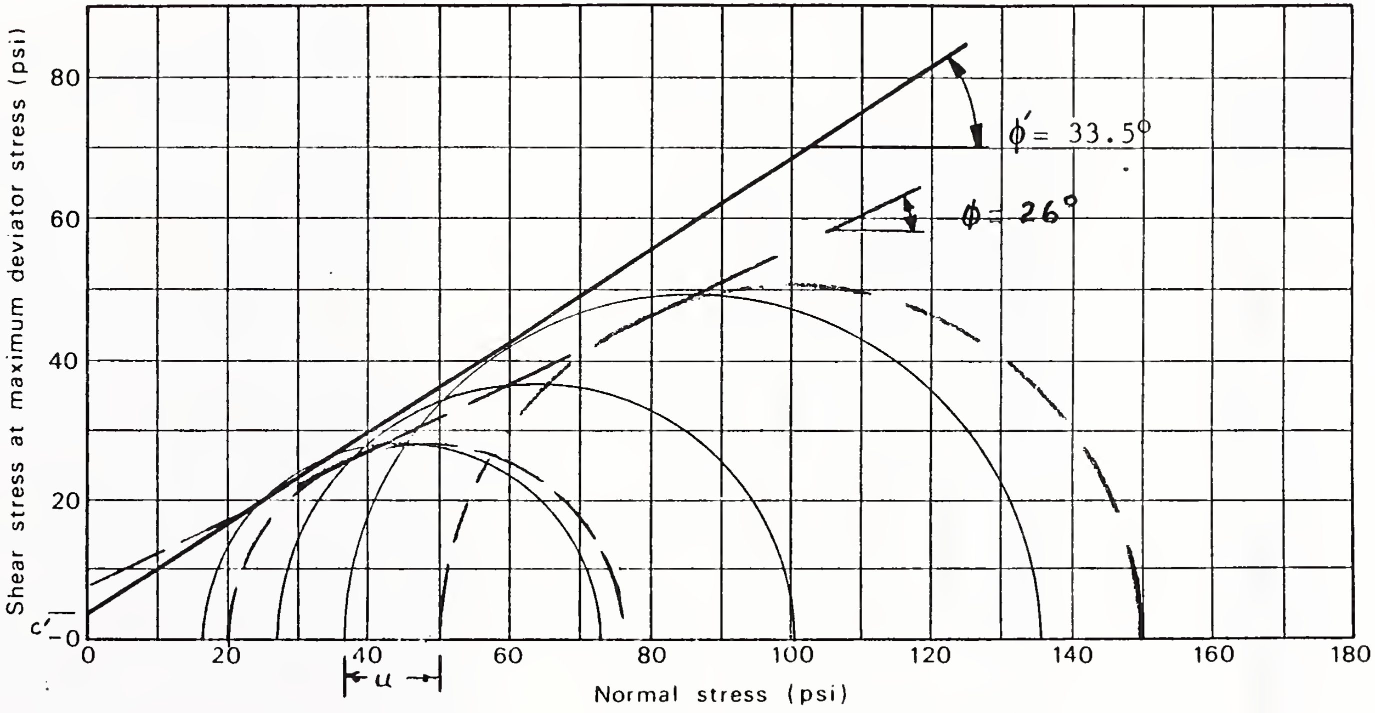


Plate No. 24







Test no. or symbol	Boring no or depth	Sample data		Degree of saturation (%)	Confining pressure (psi)	Maximum deviator stress (psi)	Strength values at failure		Sample size, L/D (inches)	Strain rate (inches/minute)
		Dry density (pcf)	Moisture content (%)				Friction angle ϕ (degrees)	Cohesion (c/psi)		
○	6A	109.7	16.4	100	20	55.1	33.5	3.5	2.8/ 1.32	.0023
△	64- 65'	109.7	16.4	100	35	73.5	33.5	3.5	5/ 2.5	.0025
□	20- 21'	109.7	16.4	100	50	100.2	33.5	3.5	5/ 2.5	.0025

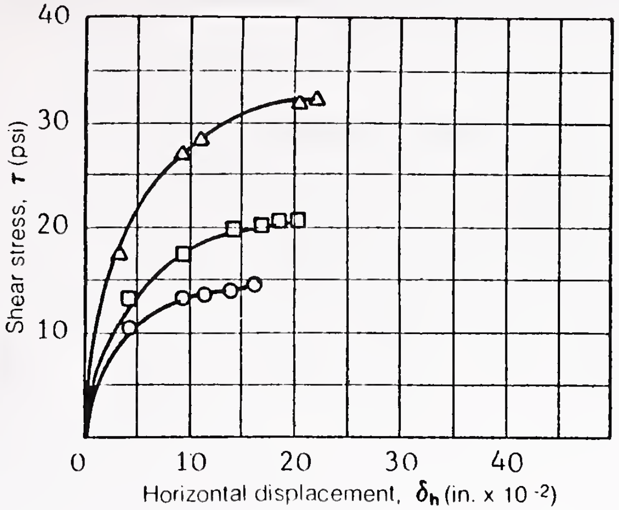
ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

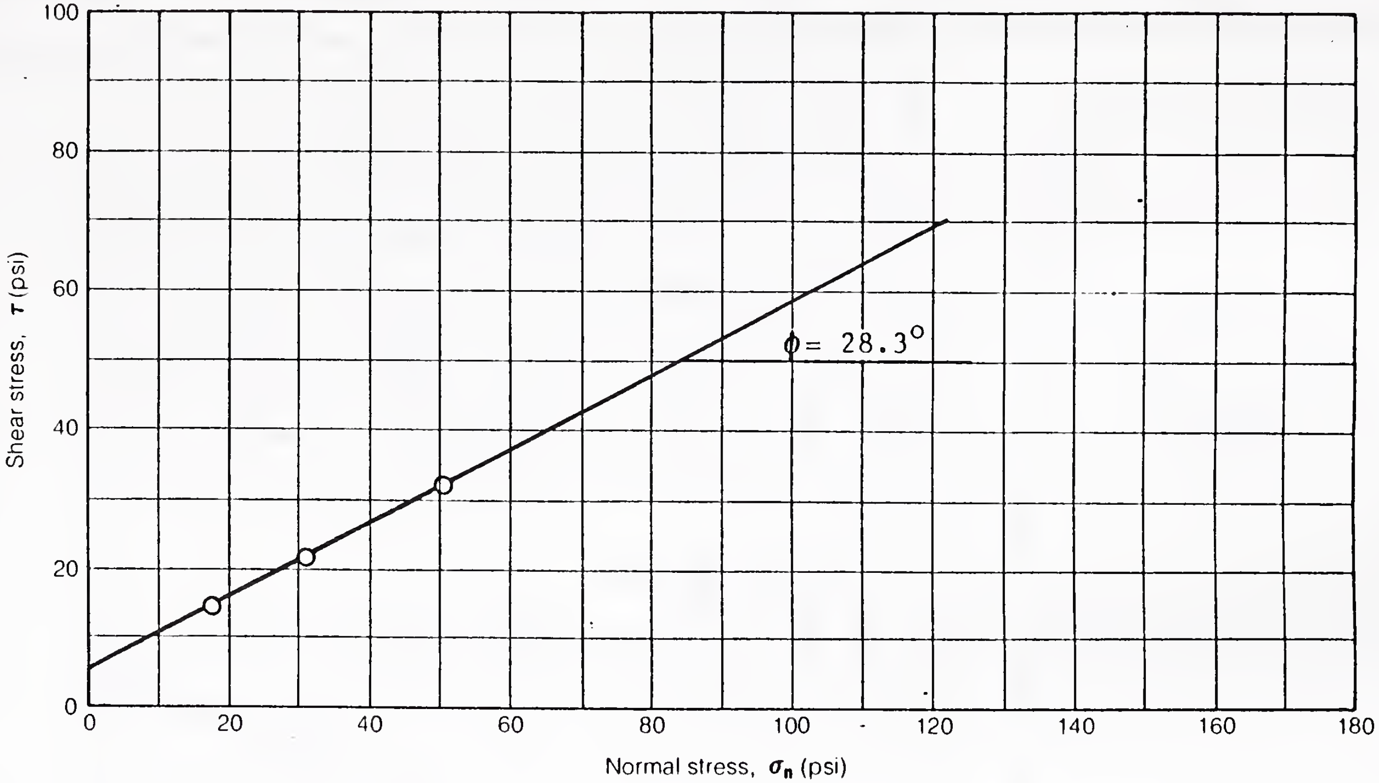
TRIAXIAL SHEAR TEST

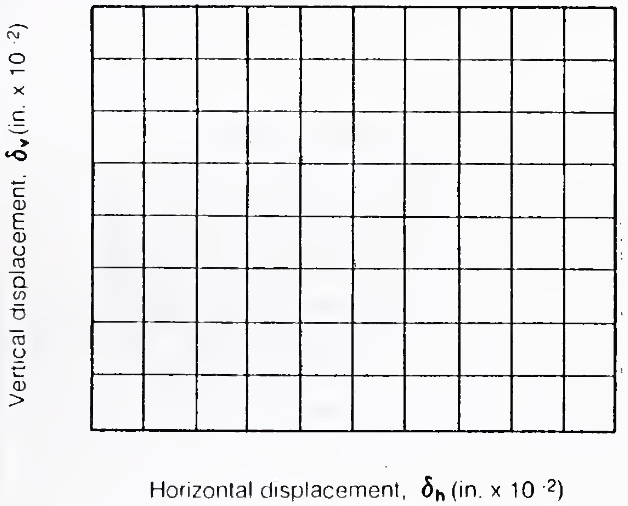
Project: Middle Creek Dam

HOLE NO. 6,6A & 7
DEPTH: Impervious zone

Plate
NO.
25







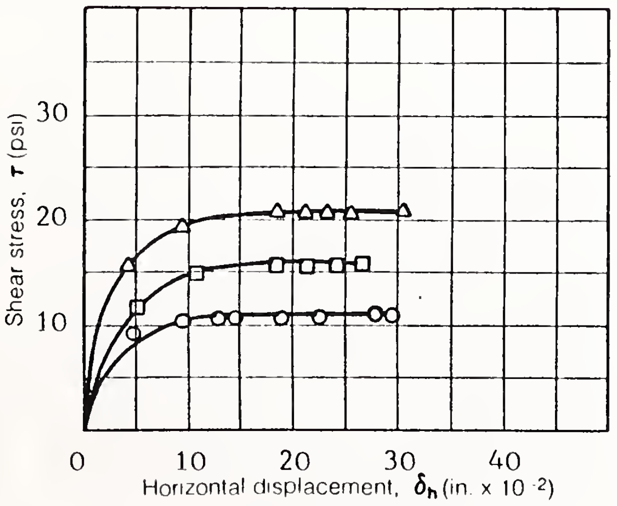
Test no. or symbol	Sample size (inches)	Sample data		Degree of saturation (%)	Normal stress σ_n (psi)	Maximum shear stress τ (psi)	Strain rate (inches / minute)	Shear strength parameters	
		Dry density (pcf)	Moisture content (%)					Friction angle ϕ (degrees)	Cohesion (c / psi)
○	2	86.8	32.8	100	17.8	14.9	.0071	28.3	5.0
□	2	86.8	32.8	100	30.6	20.9	.0071		
△	2	86.8	32.8	100	49.6	32.7	.0071		

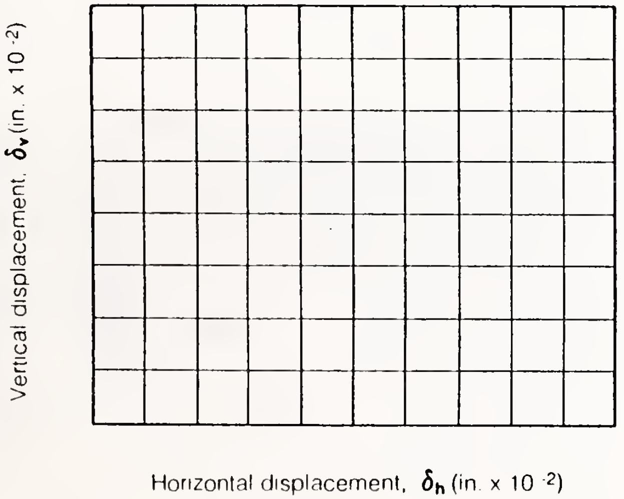
ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

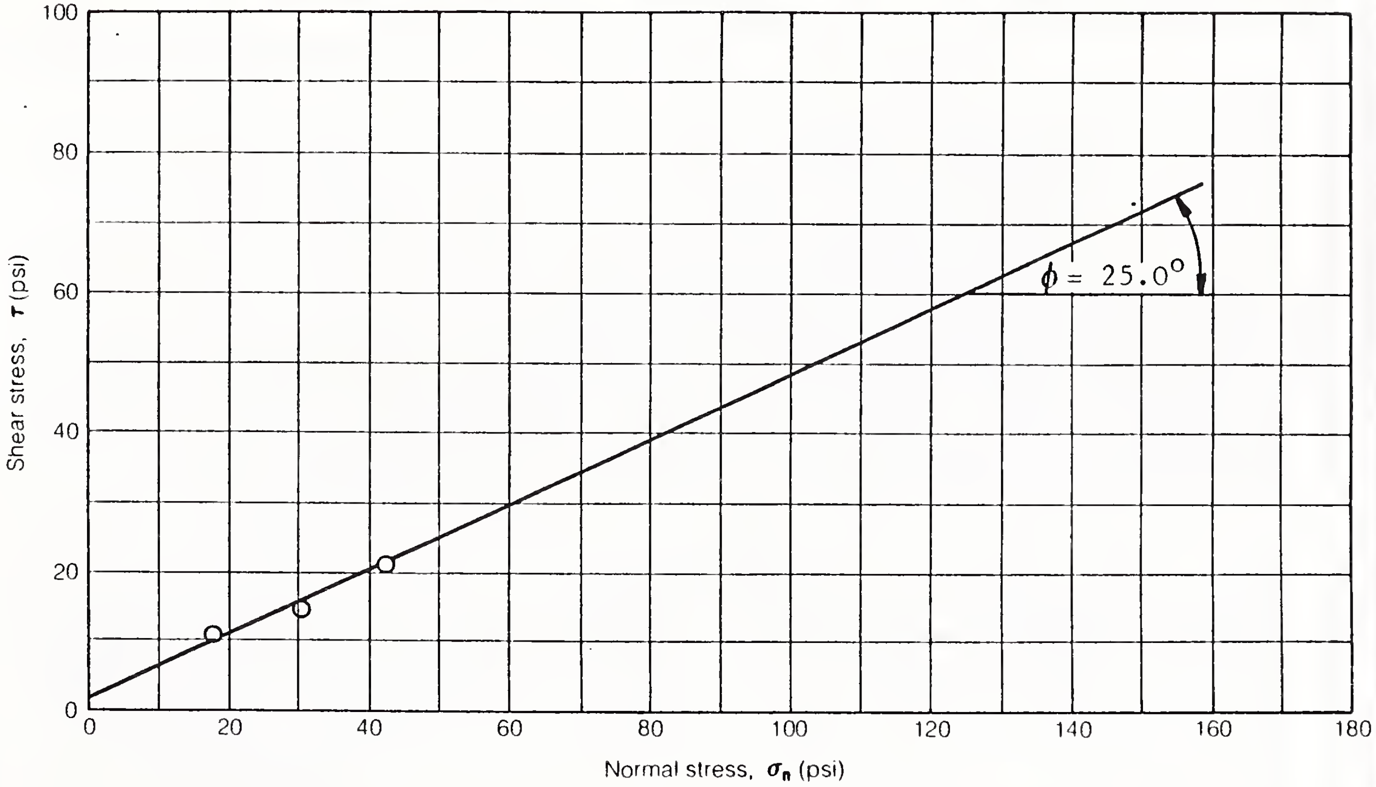
DIRECT SHEAR TEST
Project: Middle Creek Dam

HOLE NO 7
DEPTH: 87-88' (Foundation)

Plate NO. 26







Test no. or symbol	Sample size (inches)	Sample data		Degree of saturation (%)	Normal stress σ_n (psi)	Maximum shear stress τ (psi)	Strain rate (inches / minute)	Shear strength parameters	
		Dry density (pcf)	Moisture content (%)					Friction angle ϕ (degrees)	Cohesion (c / psi)
○	2	110.3	18.3	100	17.8	11.5	.0009	25.0	2.0
□	2	110.3	18.3	100	30.2	15.4	.0009		
△	2	110.3	18.3	100	42.4	21.0	.0009		

ROLLINS, BROWN AND GUNNELL, INC.
PROFESSIONAL ENGINEERS

DIRECT SHEAR TEST
Project Middle Creek Dam

HOLE NO. 14
DEPTH 32.5-33.9'
Right Abutment

Plate NO 27

FILTER FABRIC TESTING

Geoservices Inc. Consulting Engineers, 1600 Oakbrook Drive, Norcross, GA 30093 was retained to perform tests on the selected filter fabric. Results of this testing were not available at the time of printing this report. These test results will be provided separately.

APPENDIX D

APPENDIX D-1
SEEPAGE ANALYSIS

APPENDIX D-1

SEEPAGE ANALYSIS

The seepage analysis for the modified cross-section of Middle Creek Dam was investigated using the finite element seepage program SEEP2 developed by K. S. Wong and J. M. Duncan at the University of California, Berkeley. The program provides the value of the total hydraulic head at each node and the quantity of flow for heterogeneous, anisotropic systems with a free-surface. A finite element grid was created for a cross section with four material types as shown in Figure 1 and three cases were analyzed. For case one the hydraulic conductivities (Darcy permeability coefficients) in the x an y direction for each material type were as shown below:

Material Type	Kx (ft./yr.)	Ky (ft./yr.)
1	37	4
2	63	7
3	489	54
4	1600	320

The values were selected based on a review of the borehole pump tests performed during the field investigation along a cross-section defined by drill holes 4, 5, 6, and 7. The ratio of K_x to K_y has been assumed to be between 5 and 9 in order to take into account the effects of stratification on the subsurface flow.

The clay barrier wall and flexible geomembrane liner below the earth reinforced section were modeled as a completely impervious barrier and the drain below the barrier wall was modeled as a sink at a node. For case one the flow rate in the drain was 70 ft^3/yr/ft of length (0.001 gal/min) which is far below the actual capacity of the 12 inch diameter drain pipe. For flow rates in excess of this value the free-surface level dropped below the elevation of the drain. This result indicates that the drain has a

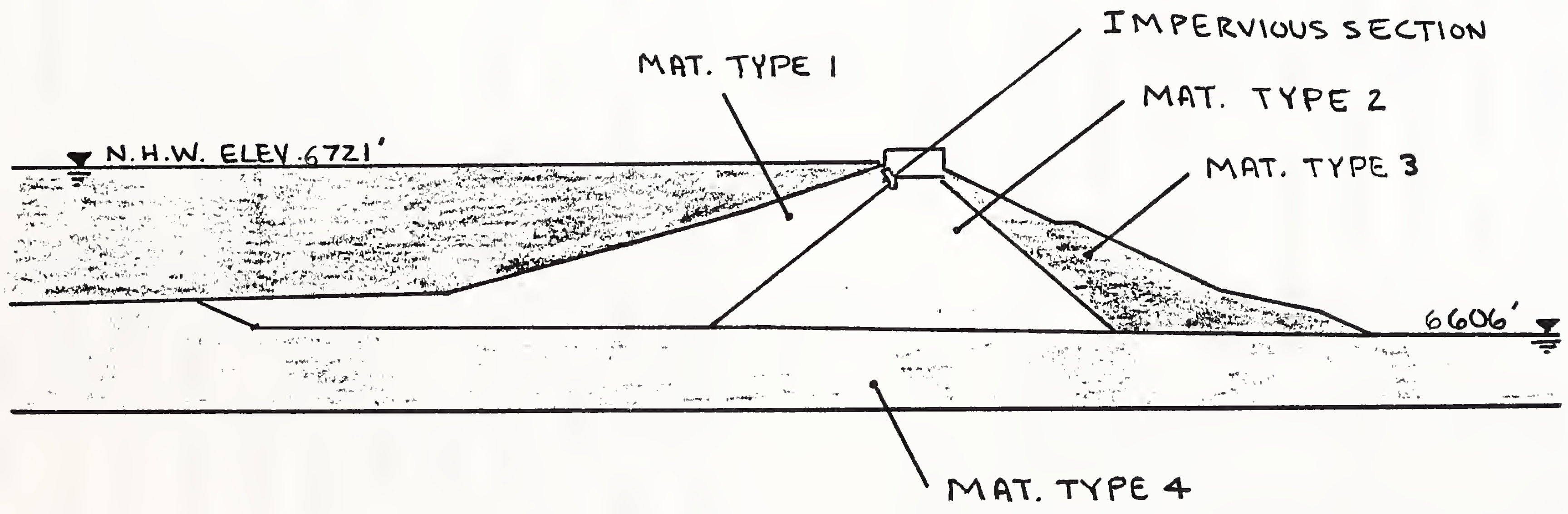

IMPERVIOUS SECTION
MAT. TYPE 1
MAT. TYPE 2
MAT. TYPE 3
N.H.W. ELEV. 6721'
6606'
MAT. TYPE 4

Figure 1 Cross-Section for Seepage Analysis

substantial excess capacity which will be available in the event that the flow regime is different than anticipated due to local variations in hydraulic conductivity.

Contours of equihydraulic head throughout the entire embankment for case one are shown in Figure 2 and an enlargement of the head distribution near the impervious trench is shown in Figure 3. It will be observed that the combination of the trench and the drain causes the free-surface downstream of the trench to remain below the base of the trench. The free-surface drops substantially as the boundary to the more pervious downstream section is reached and the free-surface intersects the downstream face of the dam at the toe of the dam. The computed flow rate through the dam for a one foot section perpendicular to the axis of the dam is 12,500 ft^3/yr. The majority of the seepage was found, as expected, to be flowing through the foundation below the embankment section (material type 4).

In order to determine the influence of a failure of the drainage system, an analysis was performed for case two assuming that the hydraulic conductivities remained the same but that the drain was no longer functional. The hydraulic headline distribution for the entire cross-section for this case is shown in Figure 4 while a close up view of the region around the trench is shown in Figure 5.

It may be seen that the free-surface rises to about 5 feet above the base of the trench on the down-stream side of the trench but that it does not reach the level of the earth reinforced section of the embankment. The elevation of the free-surface down-stream is elevated slightly but not significantly and the flow-rate through the dam remains approximately the same. Thus, a failure of the drain would provide a less desireable free-surface location but it would not likely lead to major stability problems.

KEY FOR CONTOURS (+6000)

A = 721.00
B = 709.50
C = 698.00
D = 686.50
E = 675.00
F = 663.50
G = 652.00
H = 640.00
I = 629.00
J = 617.50
K = 606.00

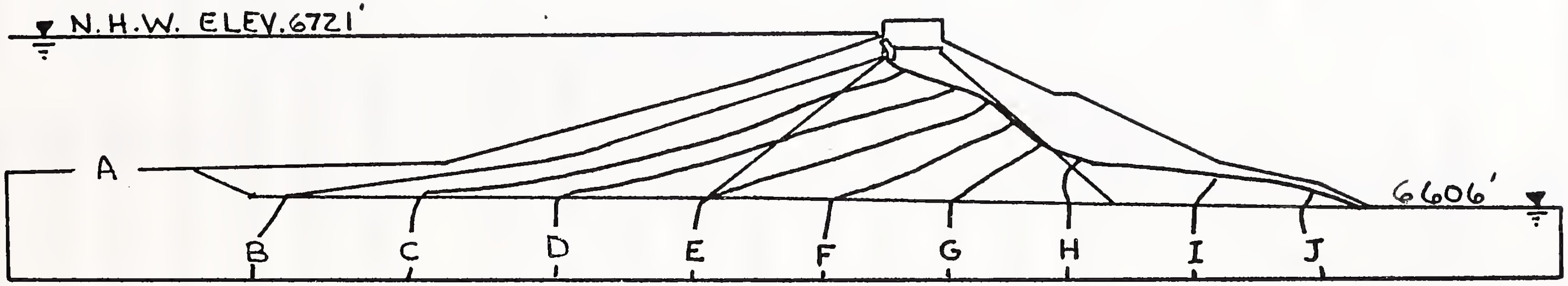

N.H.W. ELEV.6721'
A
B
C
D
E
F
G
H
I
J
6606'

Figure 2 Equihydraulic Headline Distribution for Embankment - Case one With Functioning Drain

KEY FOR CONTOURS (+6000)

A = 721.00
B = 709.50
C = 698.00
D = 686.50
E = 675.00
F = 663.50
G = 652.00
H = 640.00
I = 629.00
J = 617.50
K = 606.00

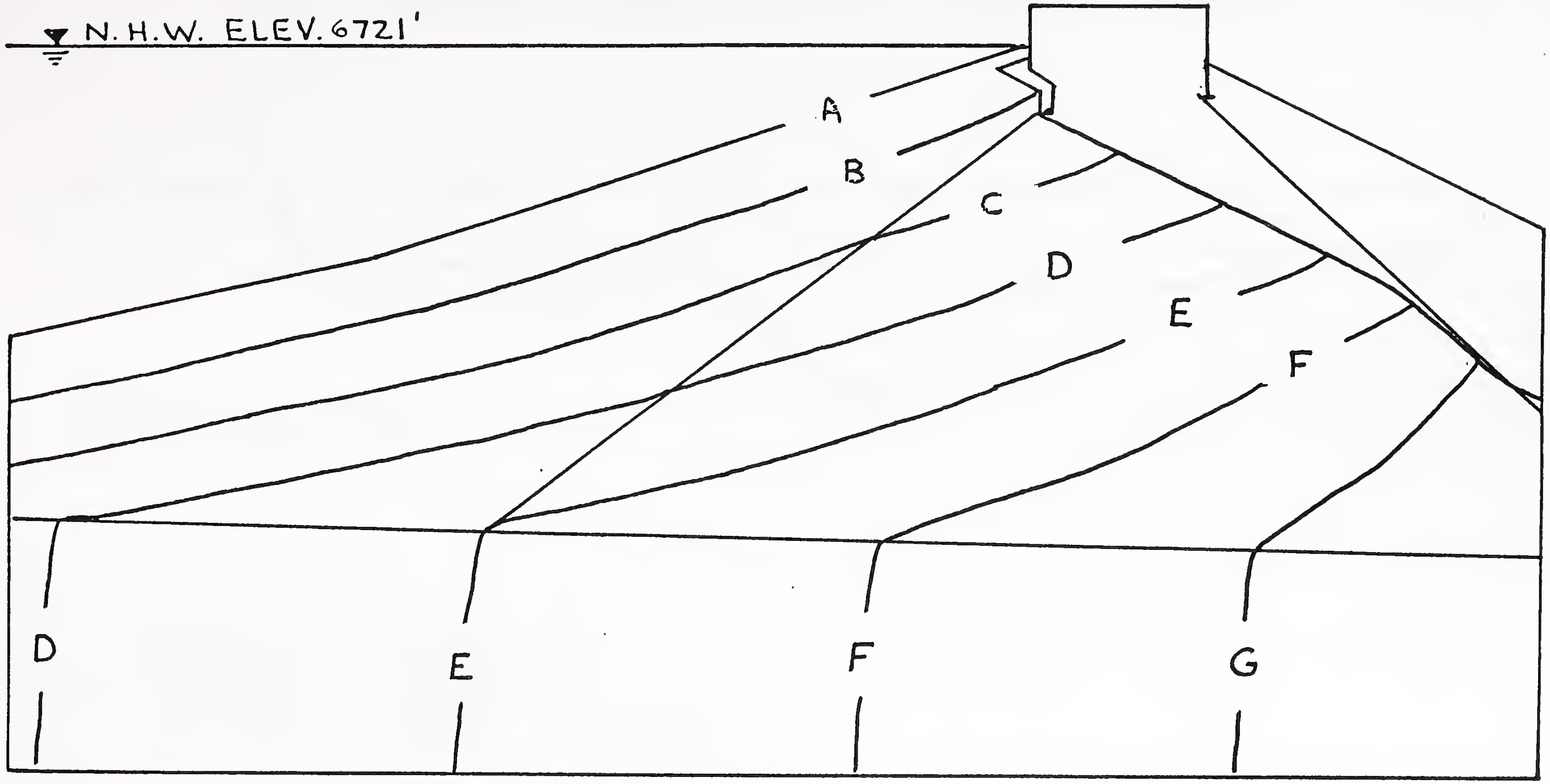

N.H.W. ELEV. 6721'
A
B
C
D
E
F
D
E
F
G

Figure 3 Equihydraulic Headline Distribution Near Trench - Case one With Functioning Drain

KEY FOR CONTOURS (+6000)

A = 721.00
B = 709.50
C = 698.00
D = 686.50
E = 675.00
F = 663.50
G = 652.00
H = 640.00
I = 629.00
J = 617.50
K = 606.00

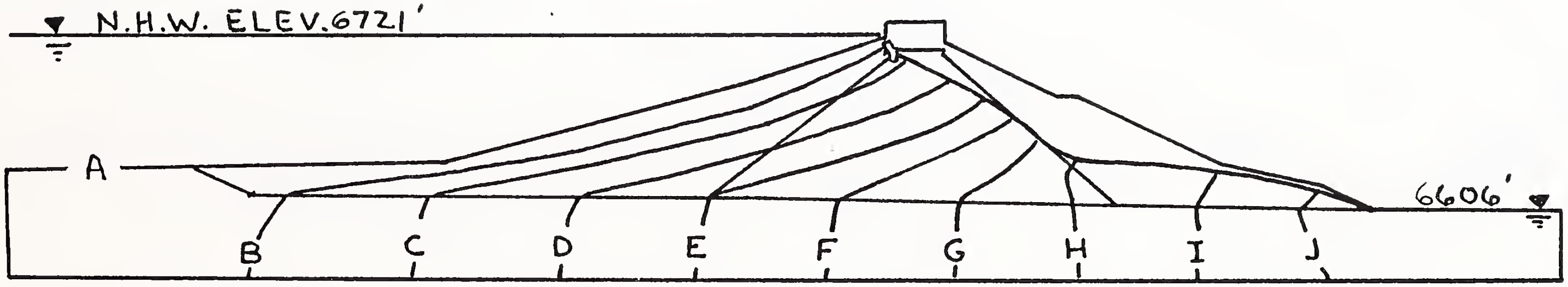

N.H.W. ELEV.6721'
A
B
C
D
E
F
G
H
I
J
6606'

Figure 4 Equihydraulic Headline Distribution for Embankment - Case two Without Drain

KEY FOR CONTOURS (+ 6000)

A = 721.00
B = 709.50
C = 698.00
D = 686.50
E = 675.00
F = 663.50
G = 652.00
H = 640.00
I = 629.00
J = 617.50
K = 606.00

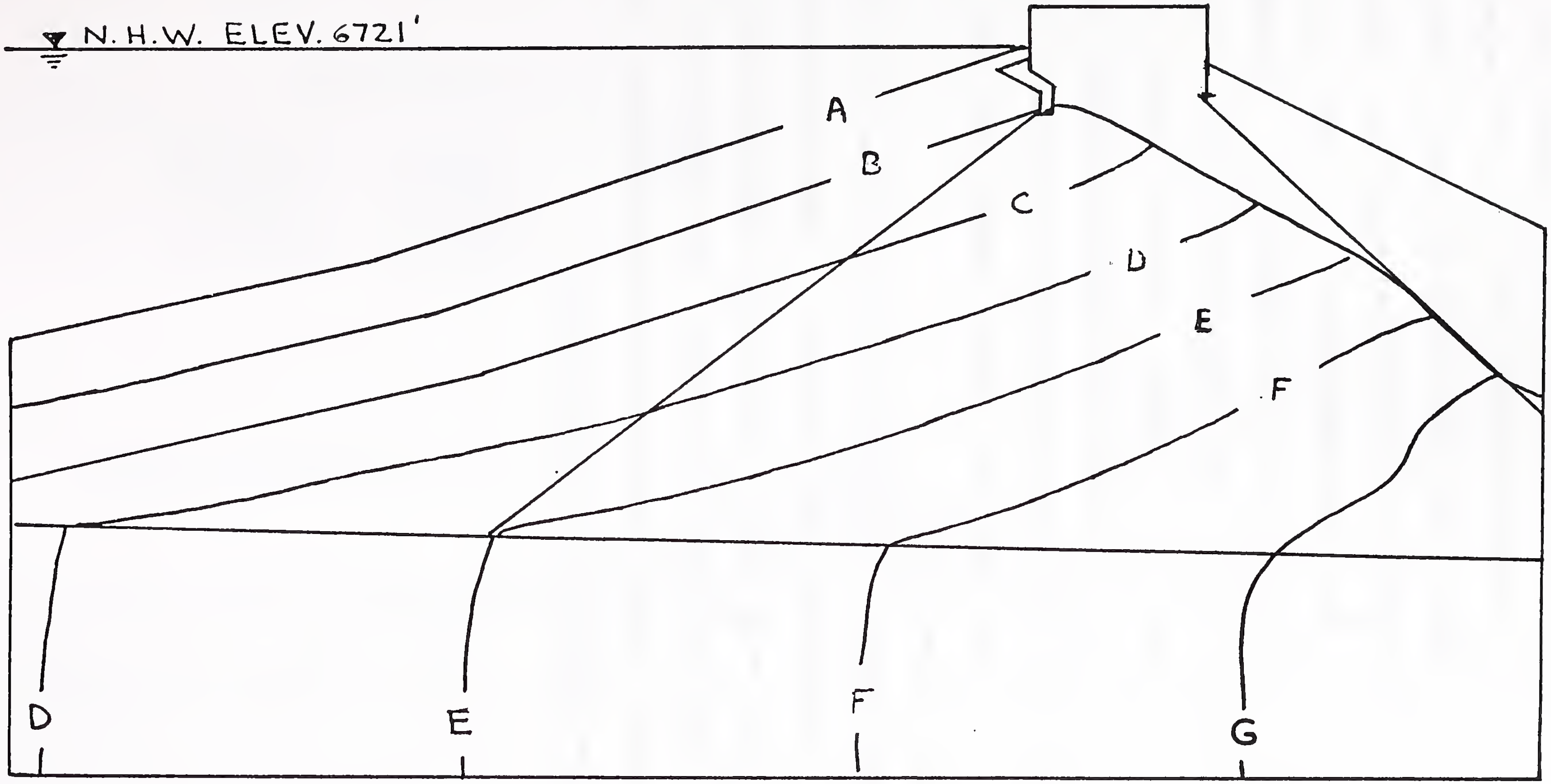

N.H.W. ELEV. 6721'
A
B
C
D
E
F
D
E
F
G

Figure 5 Equihydraulic Headline Distribution Near Trench - Case two Without Drain

Finally, the effect of decreasing the hydraulic conductivity in material types 2 and 3 in the horizontal direction to 34 and 270 respectively was investigated in case three. These lower values were used to cover the range of conductivity values observed in the field investigations. The contours of equihydraulic head for the entire embankment and the region near the trench for this case are shown in Figures 6 and 7 respectively. The effect of the change is not dramatic but the free surface drops somewhat more before the material type 3 boundary form is reached. Since the majority of the flow through the cross section is through the foundation (material type 4) the change in permeability coefficients did not alter the flow rate significantly. The flow rate in the drain pipe did increase somewhat but it was still far below the capacity of the drain.

The seepage analysis indicates that as long as the clay fill in the trench and the concrete wall panels maintain an impervious barrier to water that the reinforced earth section should remain relatively free of seepage moving up from below the base of the trench. This appears to be true even with lower hydraulic conductivity values in the central section of the dam and when the drainage system fails to operate properly.

KEY FOR CONTOURS (+6000)

A = 721.00
B = 709.50
C = 698.00
D = 686.50
E = 675.00
F = 663.50
G = 652.00
H = 640.00
I = 629.00
J = 617.50
K = 606.00

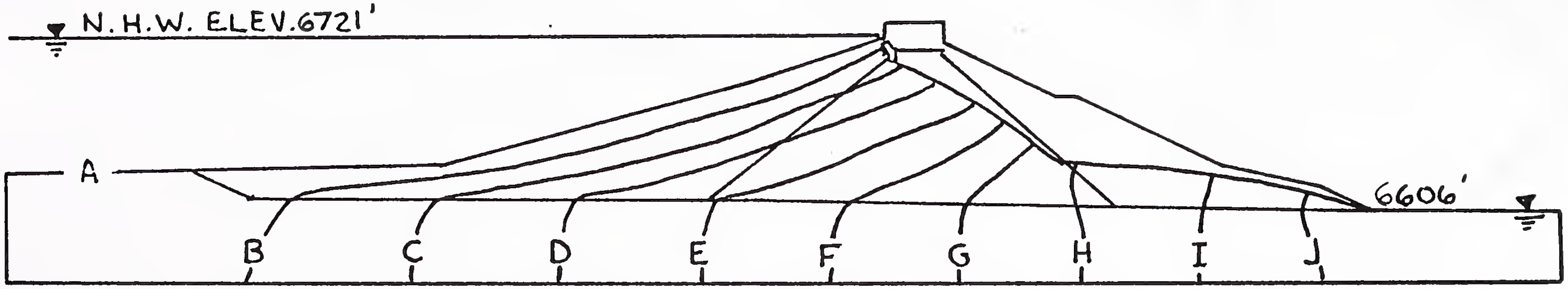

N.H.W. ELEV.6721'
A
B
C
D
E
F
G
H
I
J
6606'

Figure 6 Equihydraulic Headline Distribution for Embankment - Case three With Drain and Lower K values in Downstream Sections

KEY FOR CONTOURS (+6000)

A = 721.00
B = 709.50
C = 698.00
D = 686.50
E = 675.00
F = 663.50
G = 652.00
H = 640.00
I = 629.00
J = 617.50
K = 606.00

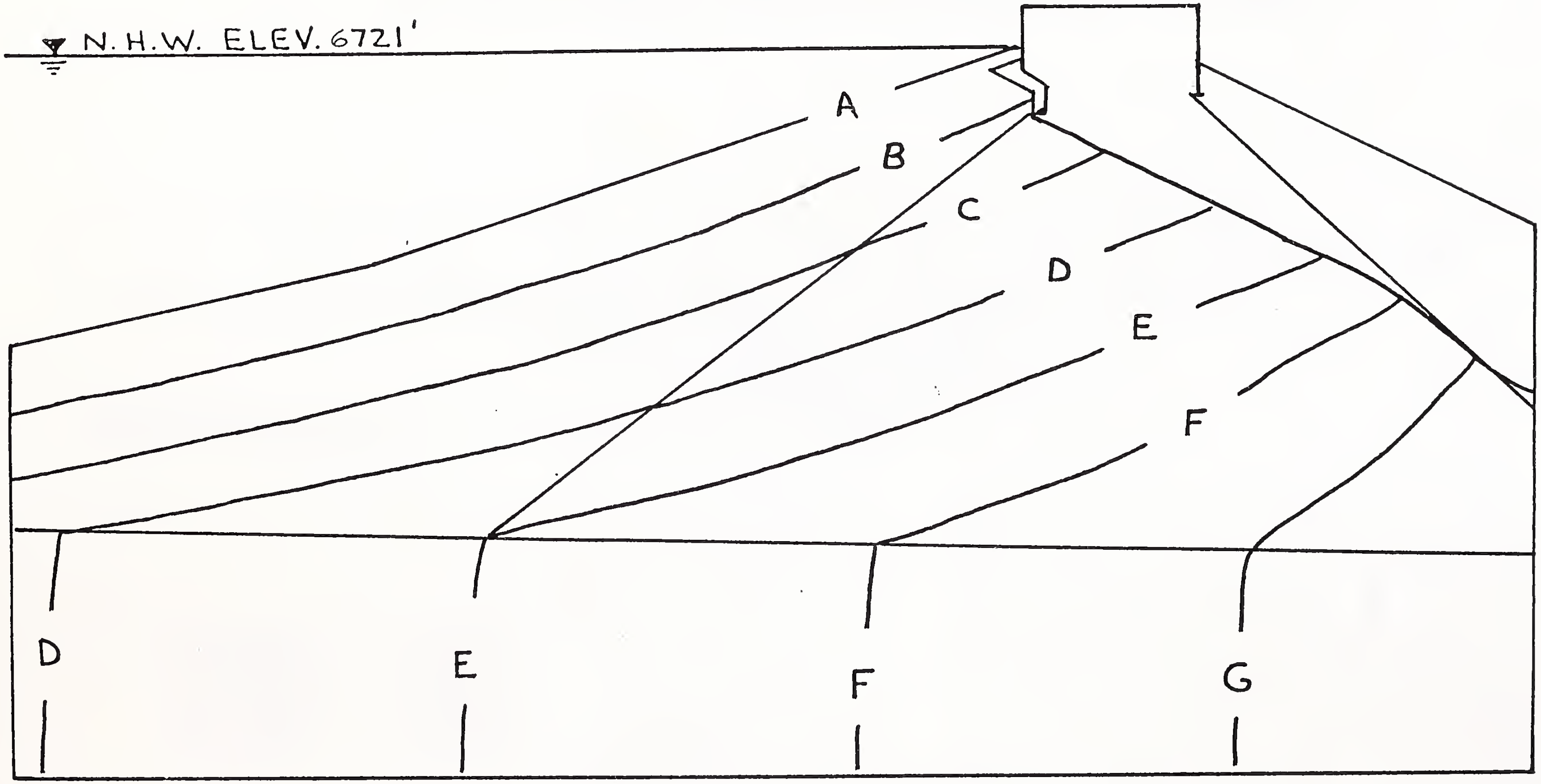


Figure 7 Equihydraulic Headline Distribution for Embankment - Case three With Drain and Lower K values in Downstream Sections

APPENDIX D-2

PIEZOMETER READING

MIDDLE CREEK DAM
GROUND WATER MEASUREMENTS

DATE	RESERVOIR ELEVATION	1	2	3A(N)	3B(S)	4A(NE)	4B(NW)	4C(S)	5	6P(N)
OP OF HOLE ELEVATION		6723.47	6722.98	6721.58	6721.58	6638.95	6638.95	6638.95	6681.66	6721.44
2/15/84	6684.2			6685.6	6684.7	6623.3	6613.3	6595.0	6651.1	6652.0
2/29/84	6684.4			6684.8	6684.1			6594.0	6649.8	6654.4
6/2/84	6700.6	6710.8		6690.7	6689.9	6627.4	6603.4	6616.3	6657.8	6652.1
9/6/84	6705.5	6708.0	6706.7	6689.6	6688.5	6622.7	6603.7	6618.7	6653.5	6653.0
1/26/85	6684.4			6685.0	6684.4	6623.1	6595.7	6613.2	6605.3	6651.6
2/23/85	6684.1		6702.1	6684.0	6689.2	6623.2	6591.4	6606.8	6604.6	6651.6
4/19/85	6684.6	6712.5	6708.4	6686.0	6684.0	6626.7	6594.6	6611.7	6611.0	6651.8
5/30/85	6709.2	6712.2	6711.0	6690.6	6689.4	6630.2	6603.2	6619.4	6608.2	6651.8
6/18/85	6710.2	6711.5	6711.6	6690.3	6689.0	6626.1	6604.2	6620.4	6607.5	6652.3
7/26/85	6691.1	6707.7	6704.3	6688.7	6687.3	6623.0	6606.3	6618.3	6603.1	6652.7
8/26/85	6685.3	6708.0	6705.0	6686.7	6686.1	6623.4	6597.7	6617.7	6602.2	6652.1
7/22/86	6712.5	6711.9	6712.1	6690.3	6688.9	6625.9	6605.2	6621.3	6651.2	6653.6
8/7/86	6702.8	6708.0	6707.5	6690.1	6690.1	6623.2	6603.7	6619.0	6649.5	6652.9
9/3/86	6687.0	6709.5	6707.0	6687.8	6686.6	6629.4	6599.4	6618.2	6650.7	6653.4
10/14/86	6687.9	6709.5	6705.2	6686.6	6686.0	6628.9	6595.8	6616.9	6649.8	6652.0
12/9/86	6688.0	6709.5	6705.2	6685.7	6685.1	6624.6	6597.0	6614.5	6646.7	6654.1
1/15/87	6690.5			6685.6	6685.1	6623.0	6597.4	6614.0	6646.7	6652.4
2/19/87	6691.0					6623.0	6597.3	6613.5	6645.2	6651.5
5/6/87	6706.2	6712.6	6711.1	6691.6	6690.5	6630.6	6603.9	6619.5	6649.0	6651.9
6/4/87	6712.8	6713.2	6712.0	6691.6	6690.3	6632.9	6607.0	6621.5	6650.7	6652.4
7/14/87	6710.2	6711.7	6710.3	6691.1	6689.9	6630.5	6605.0	6620.9	6649.8	6653.9
9/24/87	6699.4	6708.5	6705.0	6689.1	6691.9	6624.0	6603.2	6618.0	6647.2	6653.1
11/5/87	6701.0	6708.0	6703.8	6687.6	6686.6		6600.2	6617.0	6645.1	6652.4
6/14/88	6712.77	6711.5		6690.6	6689.6				6646.7	6653.1
9/7/88	6680.29	6707.0	6703.5	6686.6	6685.6				6644.0	6652.4
11/22/88	6688.76	6706.9	6703.0	6684.6	6684.6				6644.2	6651.9

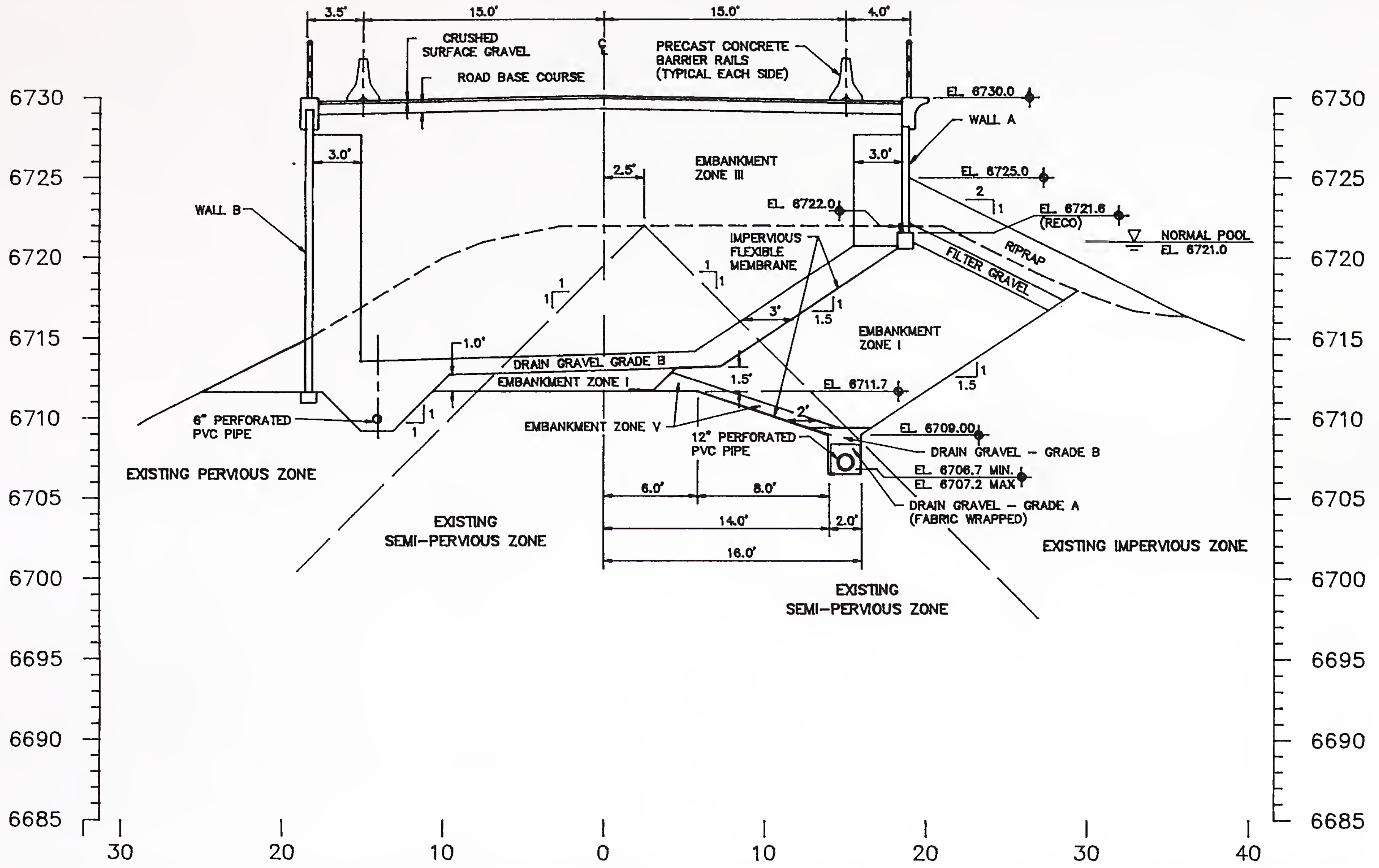
DATE	RESERVOIR ELEVATION	6(S)	8	9A(S)	9B(N)	10A(W)	10B(E)	11	12	14P(E)
OP OF HOLE ELEVATION		6721.44	6681.94	6662.10	6662.10	6721.76	6721.76	6715.76	6725.13	6683.10
2/15/84	6684.2	6621.4		6644.2	6630.2		6653.6			6656.4
2/29/84	6684.4	6620.7	6658.8		6621.6		6652.2			6651.1
6/2/84	6700.6	6626.1	6674.9	6650.3	6649.5	6691.7	6667.3			6656.4
9/6/84	6705.5	6627.0	6673.5	6650.5	6650.3	6691.5	6680.9	6702.8	6702.8	6656.3
1/26/85	6684.4	6621.8	6661.1	6644.3	6638.1				6698.3	6655.1
2/23/85	6684.1	6621.6	6661.1	6644.2	6637.4				6698.1	6655.1
4/19/85	6684.6	6627.4	6660.9	6644.4	6638.1	6691.6	6657.1		6703.2	
5/30/85	6709.2	6628.3	6676.2	6650.3	6649.8	6691.6	6676.7	6701.5	6706.0	6655.8
6/18/85	6710.2	6628.9	6675.9	6650.5	6650.4	6691.1	6676.7	6702.0	6707.3	6655.7
7/26/85	6691.1	6624.2	6679.4	6647.0	6651.6	6692.2	6666.6	6695.7	6701.9	6654.9
8/26/85	6685.3	6627.7	6662.4	6662.4	6640.4	6691.9	6659.5	6695.4	6700.8	6655.7
7/22/86	6712.5	6630.3	6674.9	6651.2	6651.2	6692.0	6675.3	6699.4	6725.1	6656.3
8/7/86	6702.8	6627.9	6672.7	6651.1	6651.3	6692.5	6670.4	6696.5	6706.6	6656.3
9/3/86	6687.0	6623.4	6663.4	6644.9	6642.1	6691.7	6660.8	6695.8	6700.9	6656.9
10/14/86	6687.9	6621.9	6661.7	6645.0	6639.0	6692.4	6654.1	6695.1	6700.1	6646.5
12/9/86	6688.0	6622.9	6662.4	6645.6	6640.1	6692.4	6654.1	6694.3	6699.2	6655.6
1/15/87	6690.5	6622.6	6662.5	6645.1	6640.1			6694.3	6699.1	6655.7
2/19/87	6691.0	6624.2	6663.4	6645.1	6639.8			6694.0	6698.9	6655.9
5/6/87	6706.2	6629.4	6677.6	6651.8	6650.3	6692.6	6677.7	6703.9	6707.4	6657.6
6/4/87	6712.8	6629.4	6676.6	6651.9	6651.7	6691.8	6676.3	6703.7	6708.4	6658.1
7/14/87	6710.2	6629.2	6675.2	6651.6	6651.3	6692.3	6673.3	6698.0	6705.5	6658.0
9/24/87	6699.4	6626.8	6672.4	6650.9	6650.4	6691.8	6669.3	6695.8	6702.1	6656.5
11/5/87	6701.0	6625.4	6669.4	6647.1	6644.6	6692.2	6665.2	6695.5	6700.1	6656.1
6/14/88	6712.77	6624.4	6675.7	6651.1	6651.1	6692.3	6674.1	6701.8	6707.1	6655.6
9/7/88	6680.29	6621.2	6659.9		6637.6	6692.3	6651.3	6694.8	6699.8	6655.7
11/22/88	6688.76	6621.1	6654.6		6630.8	6692.5	dry	6693.8	6698.9	6655.8

DATE	RESERVOIR ELEVATION	14(W)	201	202	203	204(N)	204(S)	205(W)	205(S)	206
TOP OF HOLE ELEVATION		6683.10	6634.10	6684.70	6681.90	6705.60	6705.60	6721.70	6721.70	6706.00
2/15/84	6684.2	6615.4								
2/29/84	6684.4									
6/2/84	6700.6	6615.8								
9/6/84	6705.5	6615.3								
1/26/85	6684.4	6615.3								
2/23/85	6684.1	6615.2								
4/19/85	6684.6									
5/30/85	6709.2	6615.3								
6/18/85	6710.2	6615.7								
7/26/85	6691.1	6615.6								
8/26/85	6685.3									
7/22/86	6712.5	6616.2								
8/7/86	6702.8	6615.1								
9/3/86	6687.0	6615.1								
10/14/86	6687.9	6615.1								
12/9/86	6688.0	6615.1								
1/15/87	6690.5	6615.1								
2/19/87	6691.0	6615.1								
5/6/87	6706.2	6615.1								
6/4/87	6712.8	dry								
7/14/87	6710.2	dry								
9/24/87	6699.4	dry								
11/5/87	6701.0	dry								
6/14/88	6712.77	dry	6604.1	6672.7	6646.9	6649.6	6647.3	6687.7	6648.3	6618.5
9/7/88	6680.29	dry	dry	6667.9	dry	6644.3	dry	6688.2	6640.9	6612.2
11/22/88	6688.76	dry	dry	6667.7	dry	6643.6	dry	6688.7	dry	6611.2

DATE	RESERVOIR ELEVATION	206B(S)	206B(N)	207	208
TOP OF HOLE ELEVATION		6706.00	6706.00	6705.10	6638.10
6/14/88	6712.77	6620.0	6664.3	6699.8	6607.5
9/7/88	6680.29	6614.9	6662.0	6694.0	dry
11/22/88	6688.76	6614.5	6661.0	6693.4	dry

APPENDIX D-3

BARRIER TRENCH AND EARTH REINFORCED SECTION FIGURE


3.5'
15.0'
15.0'
4.0'
CRUSHED SURFACE GRAVEL
ROAD BASE COURSE
℄
PRECAST CONCRETE BARRIER RAILS (TYPICAL EACH SIDE)
EL 6730.0
WALL A
3.0'
3.0'
2.5'
EMBANKMENT ZONE III
EL 6725.0
2
1
WALL B
EL 6722.0
EL 6721.6 (RECO)
NORMAL POOL EL 6721.0
IMPERVIOUS FLEXIBLE MEMBRANE
RIPRAP
FILTER GRAVEL
1
1
1
1
3'
1
1.5
EMBANKMENT ZONE I
1.0'
DRAIN GRAVEL GRADE B
EMBANKMENT ZONE I
1.5'
EL 6711.7
1
1.5
6" PERFORATED PVC PIPE
1
1
EMBANKMENT ZONE V
2'
12" PERFORATED PVC PIPE
EL 6709.00
DRAIN GRAVEL - GRADE B
EL 6706.7 MIN.
EL 6707.2 MAX
DRAIN GRAVEL - GRADE A (FABRIC WRAPPED)
EXISTING PERVIOUS ZONE
6.0'
8.0'
14.0'
2.0'
16.0'
EXISTING SEMI-PERVIOUS ZONE
EXISTING IMPERVIOUS ZONE
EXISTING SEMI-PERVIOUS ZONE
6730
6725
6720
6715
6710
6705
6700
6695
6690
6685
30
20
10
0
10
20
30
40

RE-FIG.DWG

MIDDLE CREEK DAM REHABILITATION
BARRIER TRENCH AND EARTH REINFORCED SECTION

APPENDIX D-3

HKM ASSOCIATES
ENGINEERS - PLANNERS

8M087.140 | AUG. 1990

APPENDIX D-4
MONITORING PLAN

APPENDIX D4

MIDDLE CREEK DAM REHABILITATION MONITORING PLAN

The locations of monitoring devices are summarized on Sheet 41 of the construction drawings.

MONITORING WELLS

All monitoring wells will be maintained in existing condition or retrofitted with vibrating wire piezometers except:

DH-11	Upstream of Left Abutment
DH-12	Auxiliary Spillway
DH-201	Principal Spillway Foundation
DH-202	Principal Spillway Foundation
DH-207	Principal Spillway Foundation

Four new vibrating wire piezometers are required along the crest to monitor the performance of the barrier trench (DH 301-304). These piezometers will be installed before construction begins.

DRAINAGE

Manholes are provided at all drain intersections to allow access for measurement and maintenance.

Flow measurement flumes are provided at the outlets of the three embankment drain systems (Manhole Type B).

SLOPE STABILITY

DH-5 and DH-208 contain slope inclinometer tubing. They will be maintained.

Earth Reinforced Structure - 4 reference points will be cast into the coping on top of each wall.

Principal Spillway Structures - Reference point will be cast into each wing wall and at all wall joints.

The following existing slope monitoring points will be maintained:

M3, M4, M7, M8, M9, M10, M11, M12

New monitoring points will be included on the new embankment. Locations are indicated on Sheet 41 of the construction drawings.

SEISMOGRAPH

A peak acceleration recorder will be installed in the embankment at the top of the maximum section to monitor the response of the embankment to seismic events.

APPENDIX D-5
FILTER DESIGNS

Project: Middle Creek
Detail: Drain and Filter Design
Sheet ___ of ___
Date
Project No.
By GCM

Drain and filter design has be accomplished utilizing accepted methods: $D_{15\,filter} \le 5 \times D_{85\,soil}$ and $D_{15_f} \ge D_{15_s}$ – Satisfying this criteria ensures the the filter will prevent piping and be permeable enough to reduce seepage forces within the embankment. Filter design followed is presented in Seepage & Drainage and Flow Nets by Cedegren second edition 1977 P 179 by

and also

Advanced Dam Design by Robert B. Jansen
Artical by John Lowe III P. 172

Check pipe perforation size:

according to Cedegren – for circular holes

$$\frac{D\,85\%\text{ of filter material}}{\text{hole diameter}} > 1.0$$

USBR – $\frac{D_{85}\text{ of filter material nearest pipe}}{\text{maximum opening of pipe}}$ = 2 or more

Pipe perforation = $\frac{3}{16}$ inch = 4.69 mm

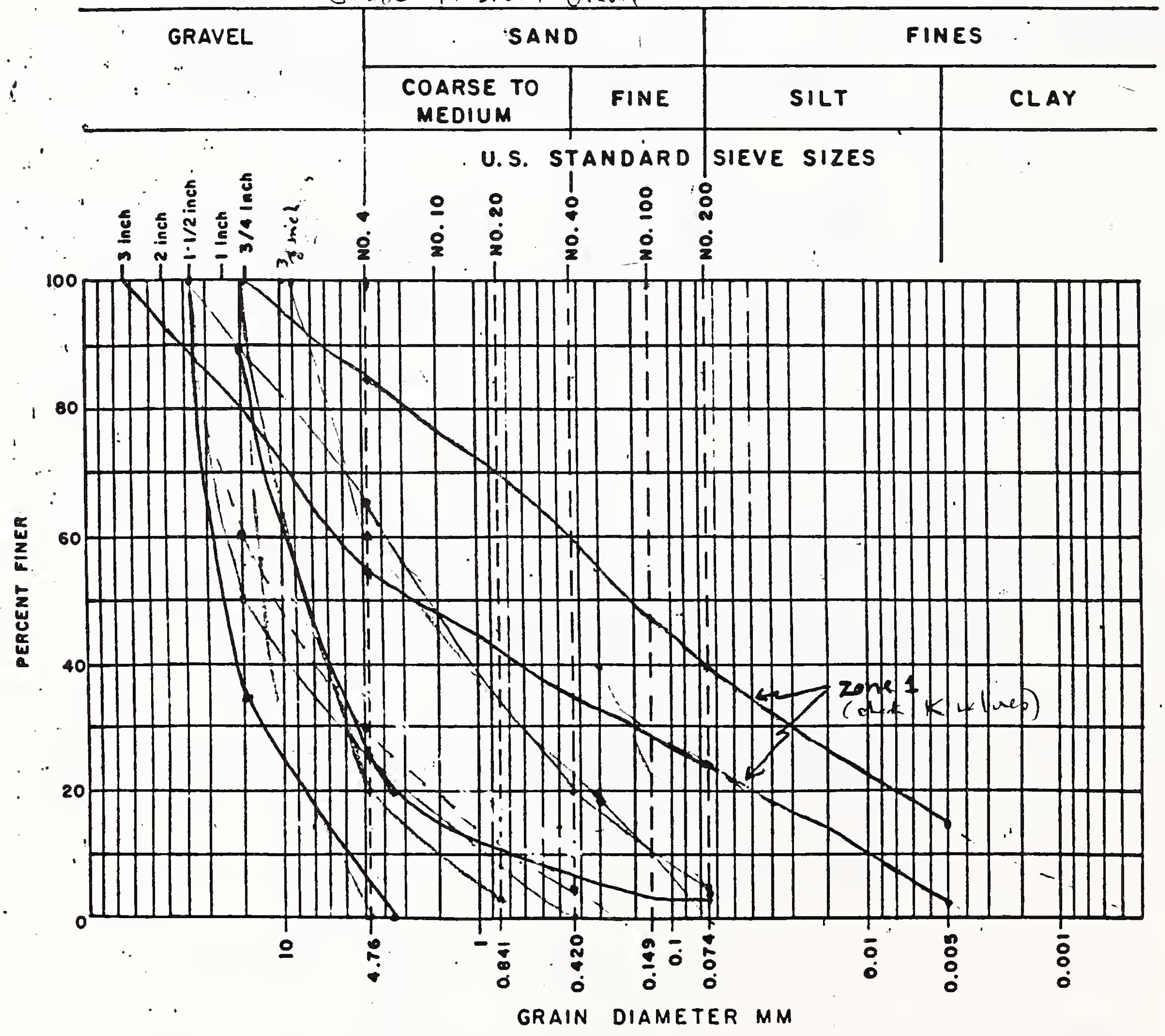
Grade B gravel – D_{85} = 12 mm $\quad \frac{12}{4.69}$ = 2.5 ok
Grade C gravel – D_{85} = 30 mm $\quad \frac{30}{4.69}$ = 6.3 ok
Grade A gravel – D_{85} = 19 mm $\quad \frac{19}{4.69}$ = 4. ok

FORM ST-5-80

HKM ASSOCIATES
ENGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. ________ LAB NO. ________
PROJECT NAME middle Creek Dam FIELD NO. ________
DATE SAMPLED ________ DATE TESTED ________
SAMPLED BY ________ TESTED BY ________
TYPE SAMPLE Compacted Sand — SAMPLE LOCATION ________
SOIL DESCRIPTION Grade B Drain Gravel - - - ← revised spec make sure it's well graded
Grade C Drain Gravel ——
Grade A Drain Gravel ——



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve ________%
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. ________%
3)_ SILT & CLAY, Passing no. 200 sieve ________%

Drain material gradations and relation
To zone 1

figure 1

FORM ST-5-80

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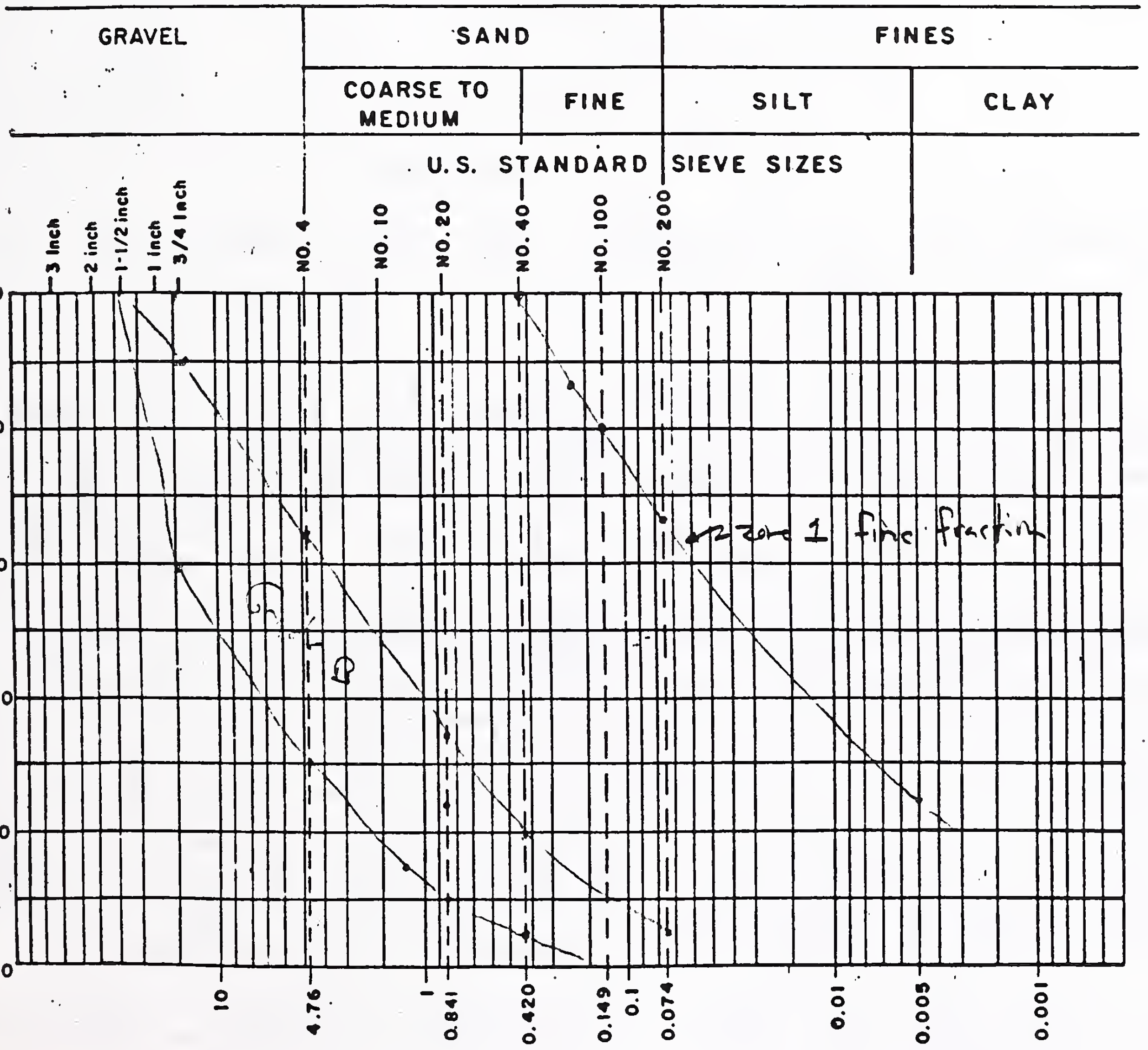
GRAIN SIZE DISTRIBUTION

PROJECT NO. ____________
PROJECT NAME middle Creek
DATE SAMPLED ____________
SAMPLED BY ____________
TYPE SAMPLE ____________
SOIL DESCRIPTION ____________
LAB NO. ____________
FIELD NO. ____________
DATE TESTED ____________
TESTED BY ____________
SAMPLE LOCATION ____________
____



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve ________%

2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. ________%

3)_ SILT & CLAY, Passing no. 200 sieve ________%

Zone 1 material —
(fine fraction)

Grade B4 filter/drain —

$D_{15_f} = 1.3$

$D_{85_s} = .25$

$D_{15_f} \leq D_{85_s} \cdot 5$ close enough!

figure 2

Project Middle Creek
Detail Drain/filter Design
Sheet 2 of
Date 7/24/90
Project No.
By GEM

right Abutment drain:

max overburden 35 ft. (Sheet 29)

Drain rock - Grade B gravel Drain Type III Drain Type V
Drain pipe - 4" or 8" perf PVC

BASE soil:	Clayey gravel with sand	D.H. 208	0'-8'
	Silty Gravel fill	D.H. 3	3'-20'
	Sandy Gravel / clayey gravel fill	D.H. 2	4'-10'
	Sandy Silt	check also D.H. 6	

Drain/filter is compatible with surrounding soils

Zone 1 Embankment: Gradation specs for zone 1 Embankment have been selected to approximate a self filtering soil. Altho the material is broadly graded, the slopes of the fine and coarse limits are steeper than 15%/5-time change in grain size. (LowE III, Advanced Dam Engineering P. 270).

An analysis has been conducted utilizing the finer fraction of the zone I grainsize curve (Passing No 40 sieve) to verify that the grade B filter/drain material will perform as a suitable filter for the zone I See Figure 2 (this is also according to LowE III P. 270)

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Project Middle Creek Dam
Detail Gradation Analysis various materials

Sheet
of ____

Date

Project No.

By GCH

Check grading on Grade B drain gravel

fine Limit - $D_{10} = .149$ $D_{15} = .25$
$D_{60} = 4.0$
$D_{30} = .70$

$$C_u = \frac{D_{60}}{D_{10}} = \frac{4}{.149} = 26.8 \qquad C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(.7)^2}{.149 \times 4.0} = .82$$

very close to well graded change D_{30} from .7 to .8 $(3 \geq C_c \geq 1)$

Coarse Limit - $D_{10} = .7$
$D_{30} = 5.0$
$D_{60} = 18$

$$C_u = \frac{D_{60}}{D_{10}} = \frac{18}{.7} = 25.7 \qquad C_c = \frac{(5)^2}{18 \times .7} = 1.98 \quad \text{ok}$$

Range of Grade B Gravel spec should insure a well graded filter/drain material that will control piping and be fairly permeable

Grade B gravel may be classified as a well graded sand with gravel with fine limit to a well graded gravel on Coarse limit

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Project Middle Creek

Detail Drain / filter Design

Sheet ___ of ___

Date 7/24/90

Project No.

By GCM

Left Abutment Drain

maximum overburden: 15 feet

Drain rock: Grade B gravel

Drain pipe: 8" perf PVC

Base Soil: Clayey Gravel DH. 10

Sandy Gravel D.H. F (24'-25')

Clayey Gravel with Sand TP 310 check 311

Drain / Filter is compatible with surrounding soils

(see attached sheets)

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Date 7/24/90

Project Middle Creek
Detail Drain/filter Design
Project No. 8M087.140
By GCM
Sheet ____ of ____

Reinforced Earth drain

maximum overburden: 21 ft

Drain rock: Grad B Gravel

Drain pipe: 6" perf PVC

Base Soil (semi pervious zone)

Silty Gravel with sand fill (D.H. 204) 0'-60'
(D.H. 206) 0'-50'

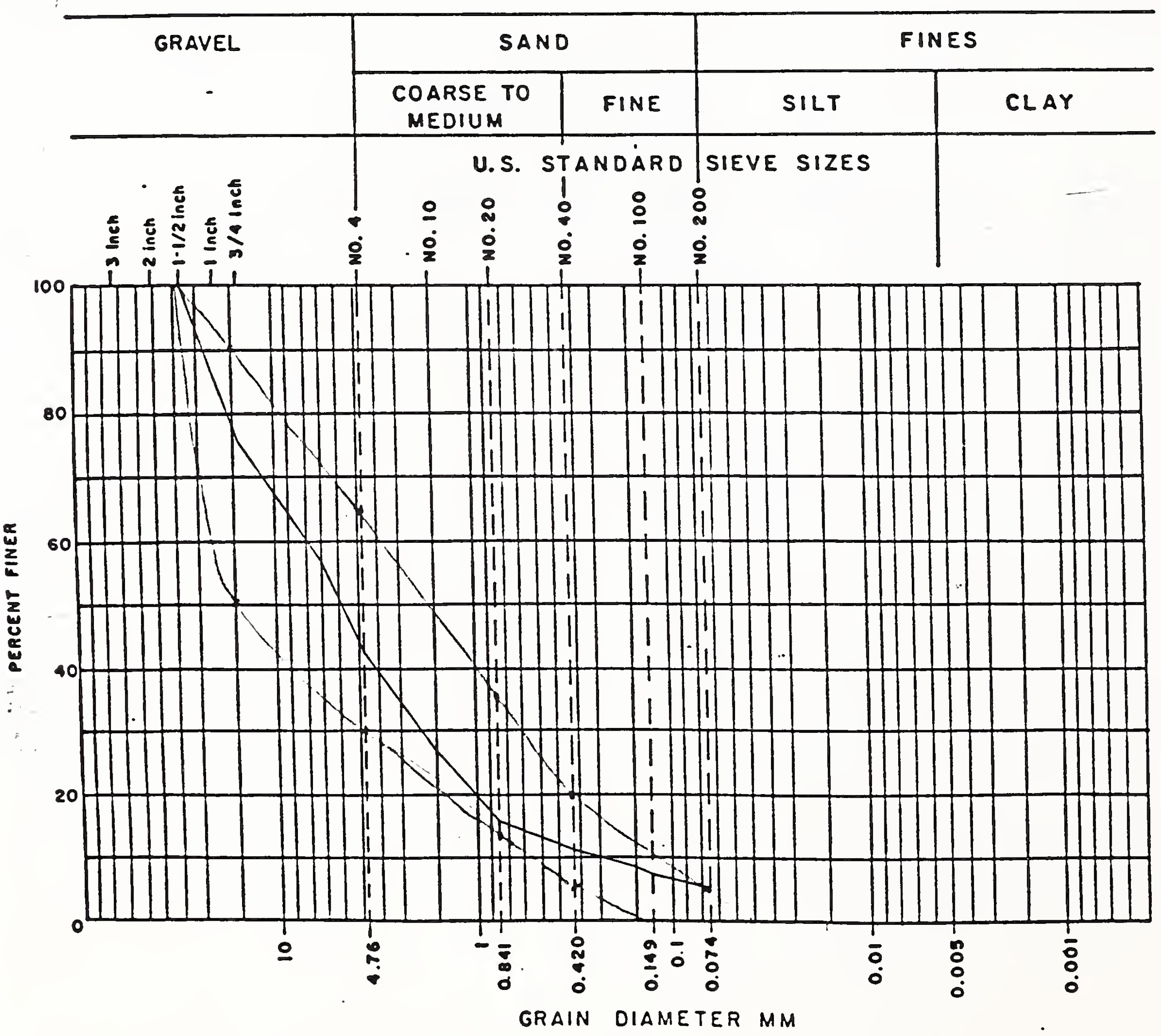
Drain/filter is compatible with surrounding soils
(see attached sheets)

FORM ST-5-80
2926

IKM ASSOCIAT
NGINEERS · ARCHITECTS · PLANNERS

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 2926
PROJECT NAME Middle Creek Dam
FIELD NO. DH-8 (24.0-25.5')
DATE SAMPLED 7-26-83
DATE TESTED October 1983
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Drive
SAMPLE LOCATION Left Abutment
SOIL DESCRIPTION SANDY GRAVEL TILL



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve 57 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 38 %
3)_ SILT & CLAY, Passing no. 200 sieve 5 %

Lt + Rt Abutment Drain (Graded Gravel)
sand

Plate No. 10

HKM ASSOCIATES
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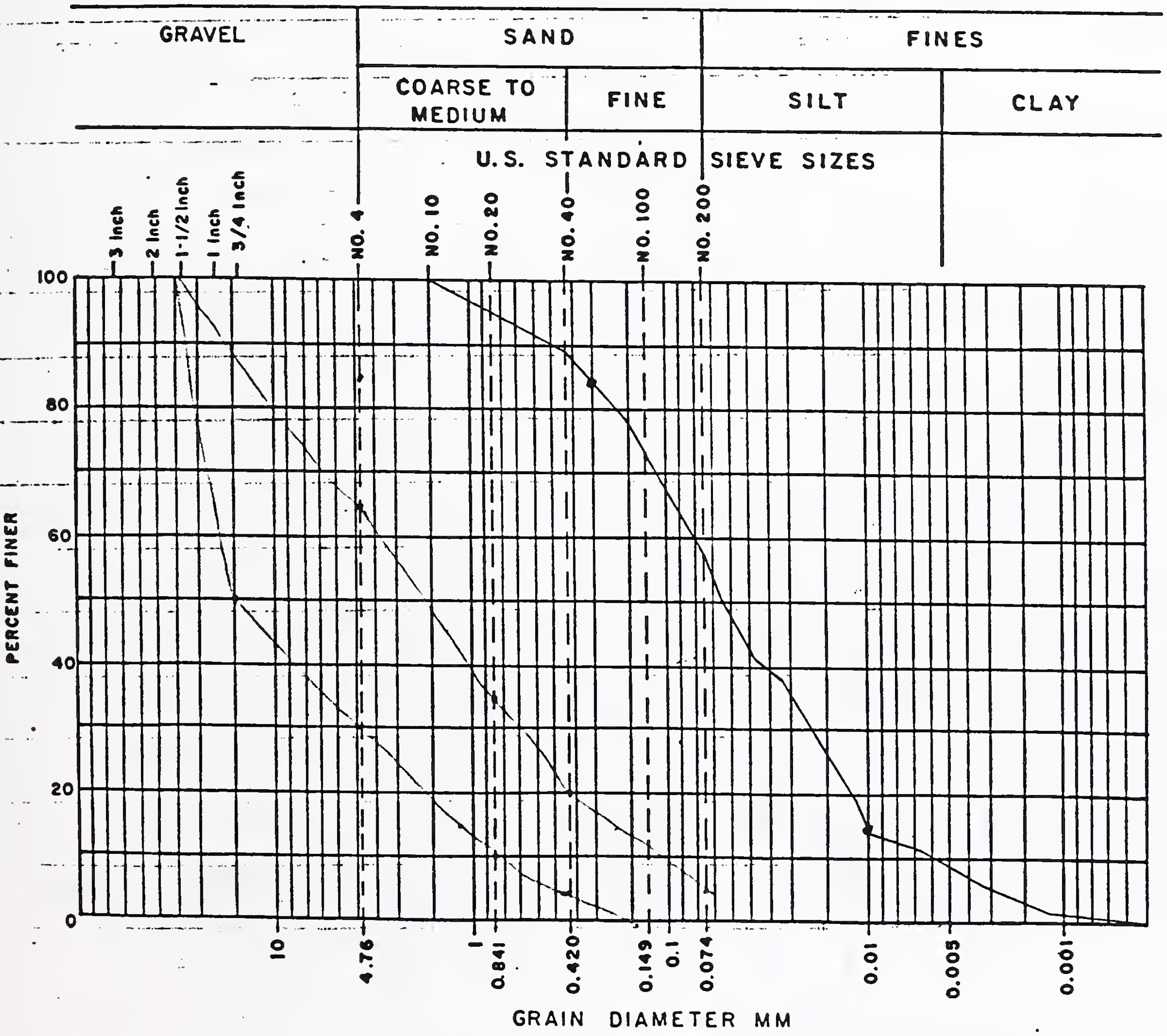
FORM ST-5-80
2912

GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 2912
PROJECT NAME Middle Creek Dam
FIELD NO. DH-6 (10.0-12.0')
DATE SAMPLED 8-3-83
DATE TESTED 9-23-83
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Drive
SAMPLE LOCATION Semi-pervious Zone
SOIL DESCRIPTION SANDY SILT (ML)



1)- GRAVEL, Passing 3" & retained on no. 4 sieve	0 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve.	42 %
3)- SILT & CLAY, Passing no. 200 sieve	58 %

Liquid Limit = 31%
Plastic Index = 4

Lt + Rt Abitment drains (Grade B Gravel + Sand)

$D_{15f} \leq 5 D_{85s}$ ok $D_{15f} = 1.3$

$D_{15f} \geq 5 D_{15s}$ ok $D_{15s} = .01$ $D_{85s} = .3$

Plate No. 3

FORM ST-5-80

2956 & 57

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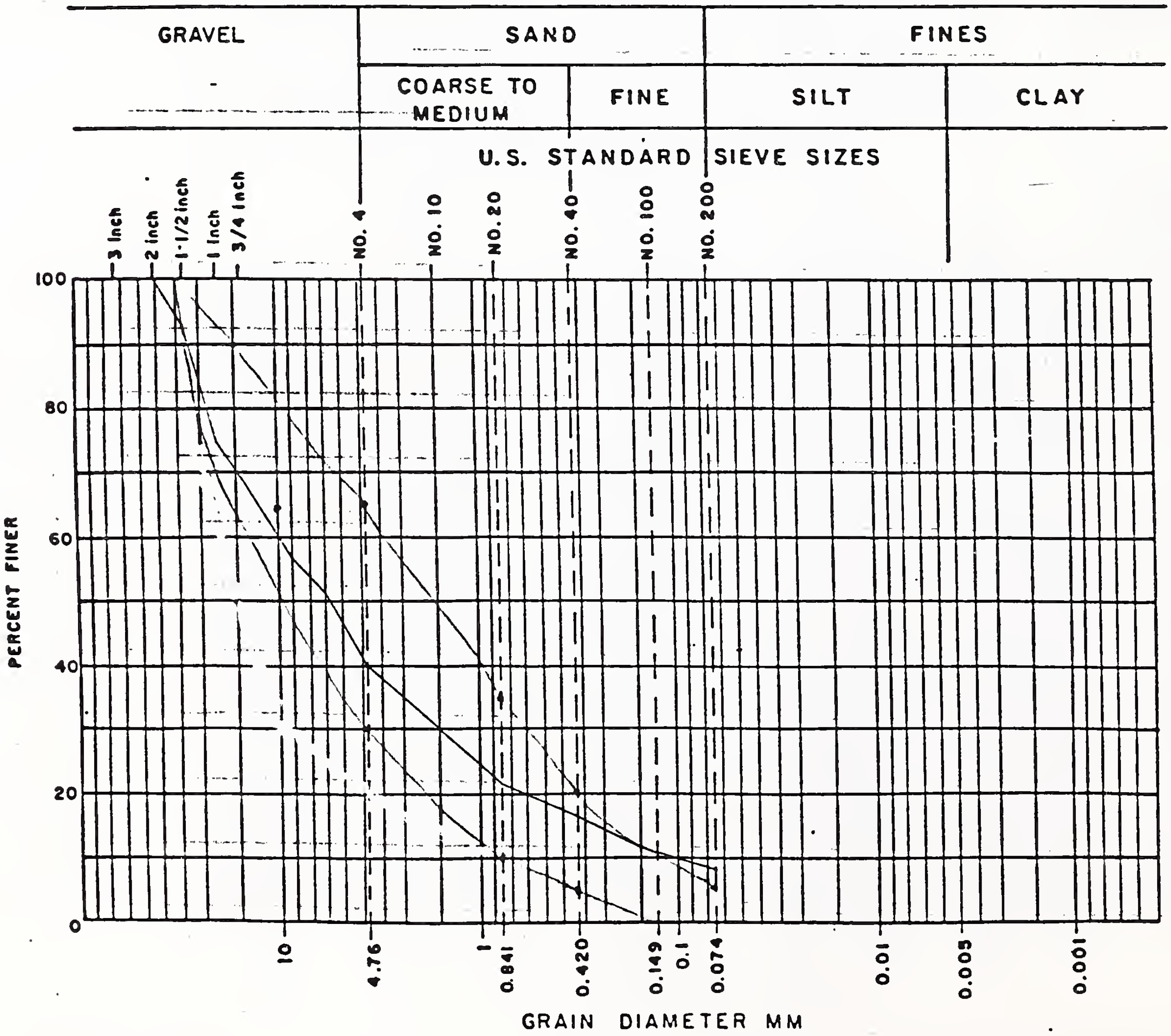
GRAIN SIZE DISTRIBUTION

PROJECT NO.	8M087.113	LAB NO.	2956
PROJECT NAME	Middle Creek Dam	FIELD NO.	DH-14 (6.0-7.5')
DATE SAMPLED	8-14-83	DATE TESTED	10-13-83
SAMPLED BY	DLD	TESTED BY	CS
TYPE SAMPLE	Drive	SAMPLE LOCATION	Pervious Zone
SOIL DESCRIPTION	SANDY GRAVEL FILL		Near Right Abutment



1)- GRAVEL, Passing 3" & retained on no. 4 sieve	60 %
2)- SAND, Passing no. 4 sieve & retained on no. 200 sieve.	32 %
3)- SILT & CLAY, Passing no. 200 sieve	8 %

Lt + rt Abutment drains (Grade B Gravel + Sand)

Plate No. 14

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COMPUTATION SHEET

By Gcn	Date	Project No. 8m087.136	Sheet 1 of 4
Chkd. By	Date	Project Name Middle Creek Dam	
Details		Feature Filter Fabric for Barrier Trench Drain	

Gradation from DH 6 10°-12° using Giroud's method:

hydraulic Conductivity of existing embankment 1×10^{-5} cm/sec

Retention Criteria

$d_0' = .006$
$d_{100}' = .60$

linear coefficient of uniformity:

$C_u' = \sqrt{d_{100}' / d_0'} = \sqrt{.6 / .006}$

$C_u = 10$

Soil Density (Compacted embankment) $I_D > 65\%$

$C_u > 3$ (Criteria P. 30)

$O_{95} \leq \frac{18}{C_u} d_{50}$ $d_{50} = .065$

$O_{95} < \frac{18 \; .065}{10}$

$O_{95} < .117$ indicates AOS > 100 sieve size

Check FHWA Criteria

$C_u = d_{60}/d_{10} = \frac{.08}{.008} = 10$

from table 2

$O_{95} < 1.8\, d_{85}$ $d_{85} = .3$

$O_{95} < 1.8\,(.3)$

$O_{95} < .54$ (seems large)

By	Date	Project No.	Sheet 2 of 4
Chkd. By	Date	Project Name Middle Creek Dam	
Details		Feature	

Permeability Requirements

compressive stress say 35 ft over @ 135 $^{lb}/_{ft^3}$ $\sigma = 4{,}725$ $^{lb}/_{ft^2}$

Permeability needed $K_g > 10 K_s$ $K_s \cong 1 \times 10^{-5}$ cm/sec

$K_g > 10\,(1 \times 10^{-5})$

$K_g > 1 \times 10^{-4}$ should be plenty

$K_g \cong .4$ cm/sec

Porosity should be no problem

Probably should use a nonwoven needlepunch
with AOS ×100 use Supac 10NP

Sheet 3/4

FORM ST-5-80

2912

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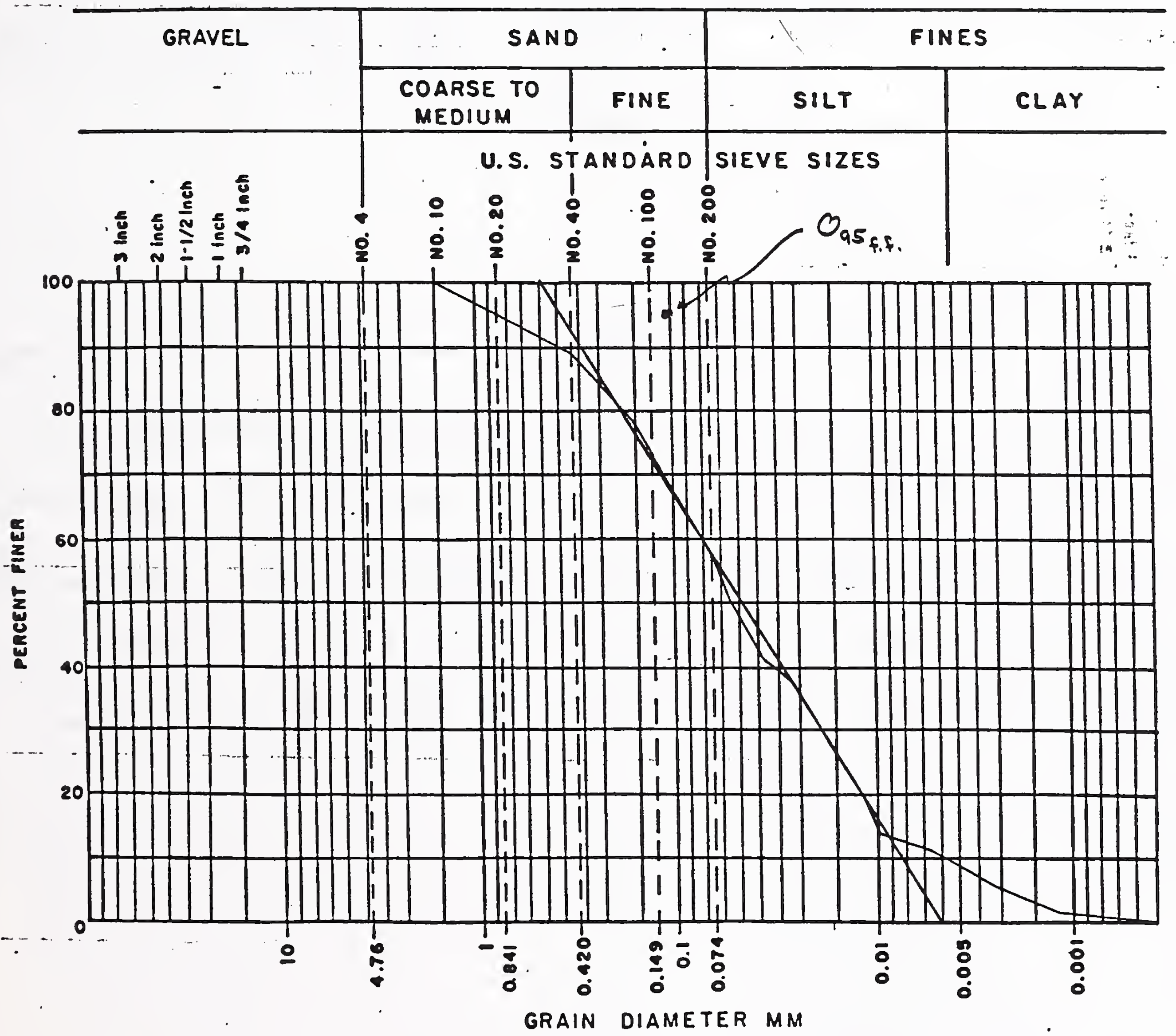
GRAIN SIZE DISTRIBUTION

PROJECT NO. 8M087.113
LAB NO. 2912
PROJECT NAME Middle Creek Dam
FIELD NO. DH-6 (10.0-12.0')
DATE SAMPLED 8-3-83
DATE TESTED 9-23-83
SAMPLED BY DLD
TESTED BY CS
TYPE SAMPLE Drive
SAMPLE LOCATION Semi-pervious Zone
SOIL DESCRIPTION SANDY SILT (ML)



1)_ GRAVEL, Passing 3" & retained on no. 4 sieve 0 %
2)_ SAND, Passing no. 4 sieve & retained on no. 200 sieve. 42 %
3)_ SILT & CLAY, Passing no. 200 sieve 58 %

Liquid Limit = 31%
Plastic Index = 4

Plate No. 3

Project

Detail Middle Creek Dam - Filter fabric (Barrier trench

Sheet 4 of 4

Date

Project No. 8M087.140

By Gcm

Filter fabric Selection using USBR criteria. (from P.P. 185-186 Advanced Dam Engineering, Jansen)

Piping Resistance Criteria (use gradation D.H. 6 10'-12' as representative)

greater than 50% passing No. 200 sieve

nonwovens $O_{95} \le 1.8 D_{85}$

D_{85} = base soil
O_{95} = fabric opening size (AOS)

D_{85} = .30 mm (gradation curve)

$O_{15} \le 1.8(.30)$

$O_{95} \le 5.40$ mm

using AOS ≈ .149 mm (No. 100 sieve) more than meets this requiremen

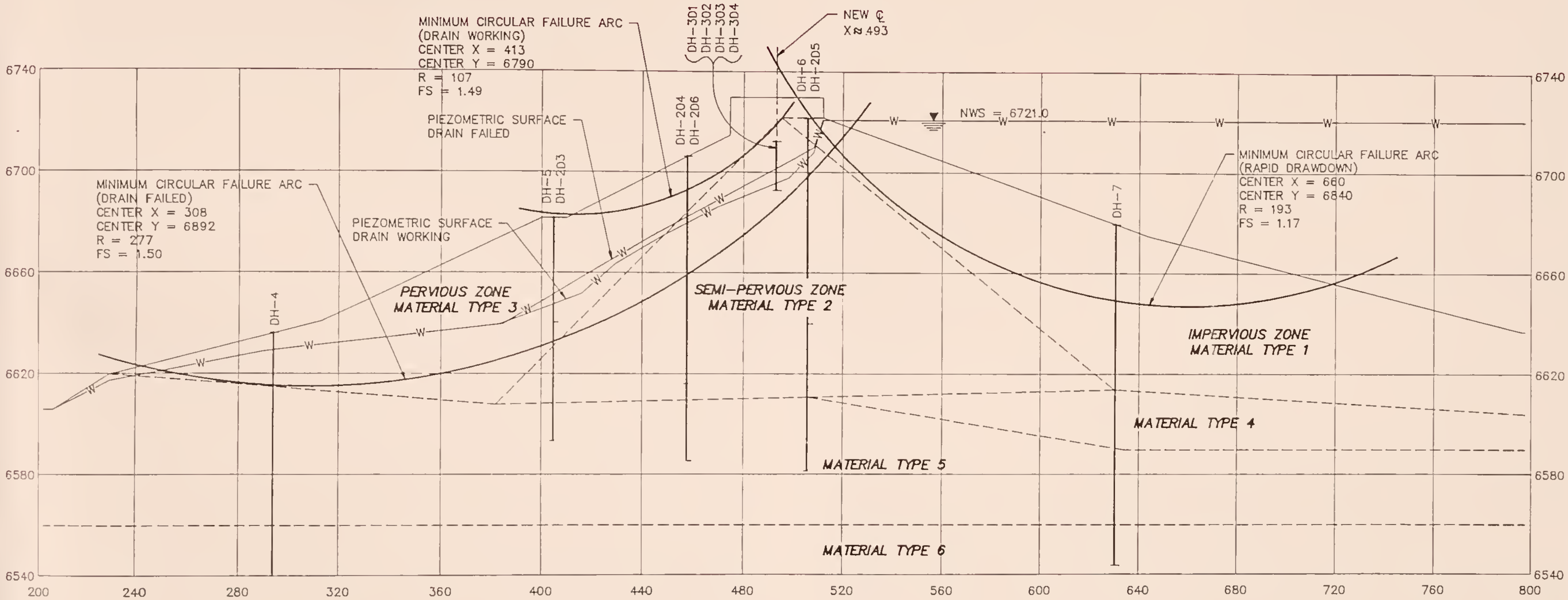
According to Giroud's method conducted previously The required AOS = .117 which is less than (No. 100 sieve) Giroud does state that his method may be conservative for clayey soils. much of the material in the dam contains Clay. AOS ≈ 100 appears to be a reasonable parameter.

FILTER FABRIC TESTING

Geoservices Inc. Consulting Engineers, 1600 Oakbrook Drive, Norcross, GA 30093 was retained to perform tests on the selected filter fabric. Results of this testing were not available at the time of printing this report. These test results will be provided separately.

APPENDIX D-6
SLOPE STABILITY

Stability Cross Section (11 x 17 figure sheet)
Downstream Face Computer Printout
Upstream Face Computer Printout


MINIMUM CIRCULAR FAILURE ARC
(DRAIN WORKING)
CENTER X = 413
CENTER Y = 6790
R = 107
FS = 1.49
DH-301
DH-302
DH-303
DH-304
NEW ℄
X≈493
DH-6
DH-205
PIEZOMETRIC SURFACE
DRAIN FAILED
NWS = 6721.0
DH-204
DH-206
MINIMUM CIRCULAR FAILURE ARC
(RAPID DRAWDOWN)
CENTER X = 660
CENTER Y = 6840
R = 193
FS = 1.17
MINIMUM CIRCULAR FAILURE ARC
(DRAIN FAILED)
CENTER X = 308
CENTER Y = 6892
R = 277
FS = 1.50
DH-5
DH-203
PIEZOMETRIC SURFACE
DRAIN WORKING
DH-7
PERVIOUS ZONE
MATERIAL TYPE 3
SEMI-PERVIOUS ZONE
MATERIAL TYPE 2
DH-4
IMPERVIOUS ZONE
MATERIAL TYPE 1
MATERIAL TYPE 4
MATERIAL TYPE 5
MATERIAL TYPE 6
W
6740
6700
6660
6620
6580
6540
200
240
280
320
360
400
440
480
520
560
600
640
680
720
760
800

STABANEX.DWG

MIDDLE CREEK DAM REHABILITATION
FINAL STABILITY ANALYSES CROSS SECTION

HKM ASSOCIATES
ENGINEERS · PLANNERS

8M087.140	OCTOBER 1990

DOWNSTREAM FACE

FINAL STABILITY ANALYSIS

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
TABLE NO. 1
******************************************
* COMPUTER PROGRAM DESIGNATION - UTEXAS2 *
* Originally Coded By Stephen G. Wright  *
* Version No. 1.211                      *
* Last Revision Date  4/10/87            *
* Serial No. NONE                        *
* (C) Copyright 1985 Stephen G. Wright   *
* All Rights Reserved                    *
******************************************

**************************************************************
*                                                            *
*      RESULTS OF COMPUTATIONS PERFORMED USING THIS COMPUTER *
* PROGRAM SHOULD NOT BE USED FOR DESIGN PURPOSES UNLESS THEY *
* HAVE BEEN VERIFIED BY INDEPENDENT ANALYSES, EXPERIMENTAL   *
* DATA OR FIELD EXPERIENCE. THE USER SHOULD UNDERSTAND THE   *
* ALGORITHMS AND ANALYTICAL PROCEDURES USED IN THE COMPUTER  *
* PROGRAM AND MUST HAVE READ ALL DOCUMENTATION FOR THIS      *
* PROGRAM BEFORE ATTEMPTING ITS USE.                         *
*                                                            *
*      NEITHER THE UNIVERSITY OF TEXAS NOR STEPHEN G. WRIGHT *
* MAKE OR ASSUME LIABILITY FOR ANY WARRANTIES, EXPRESSED OR  *
* IMPLIED, CONCERNING THE ACCURACY, RELIABILITY, USEFULNESS  *
* OR ADAPTABILITY OF THIS COMPUTER PROGRAM.                  *
*                                                            *
**************************************************************
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO.  2
*************************
* NEW PROFILE LINE DATA *
*************************

PROFILE LINE  1 - MATERIAL TYPE =  6
SUB-FOUNDATION LAYER (LOWEST)

     Point       X             Y

       1     -5000.000       560.000
       2      5000.000       560.000

PROFILE LINE  2 - MATERIAL TYPE =  5
FOUNDATION LAYER

     Point       X             Y

       1     -5000.000       606.000
       2       206.000       606.000
       3       230.000       620.000
       4       382.000       608.000
       5       506.000       611.000
       6       634.000       590.000
       7      5000.000       590.000

PROFILE LINE  3 - MATERIAL TYPE =  4
UP-STREAM FOUNDATION LAYER

     Point       X             Y

       1       506.000       611.000
       2       630.000       614.000
       3       916.000       597.000
       4       943.000       632.000
       5      5000.000       632.000

PROFILE LINE  4 - MATERIAL TYPE =  3
DOWN STREAM FACE OF DAM

     Point       X             Y

       1       230.000       620.000
       2       313.000       641.000
       3       400.000       682.000
       4       410.000       682.000
       5       474.500       715.000
       6      474.500      730.000
       7      512.000      730.000
       8      512.000      722.000

PROFILE LINE  5 - MATERIAL TYPE =  2
CORE OF DAM

     Point       X             Y

       1      382.000      608.000
       2      495.000      722.000
       3      630.000      614.000

PROFILE LINE  6 - MATERIAL TYPE =  1
UP-STREAM FACE OF DAM

     Point       X             Y

       1      495.000      722.000
       2      512.000      722.000
       3      644.000      675.000
       4      796.000      637.000
       5      943.000      632.000

All new profile lines defined - No old lines retained
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO.  3
******************************
* NEW MATERIAL PROPERTY DATA *
******************************

DATA FOR MATERIAL TYPE  1
UP-STREAM FACE OF DAM

     Unit weight of material =  120.000

     CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
     Cohesion - - - - - - - -     200.000
     Friction angle - - - - -  32.500 degrees

     Pore water pressures defined by piezometric line
     Number of the piezometric line used =  1
     Negative pore pressures set to zero

DATA FOR MATERIAL TYPE  2
CORE OF DAM

     Unit weight of material =  125.000

     CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
     Cohesion - - - - - - - -      20.000
     Friction angle - - - - -  35.000 degrees

     Pore water pressures defined by piezometric line
     Number of the piezometric line used =  1
     Negative pore pressures set to zero

DATA FOR MATERIAL TYPE  3
DOWN-STREAM FACE OF DAM

     Unit weight of material =  125.000

     CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
     Cohesion - - - - - - - -      20.000
     Friction angle - - - - -  35.000 degrees

     Pore water pressures defined by piezometric line
     Number of the piezometric line used =  1
     Negative pore pressures set to zero

DATA FOR MATERIAL TYPE  4
UP-STREAM FOUNDATION LAYER
```

```
     Unit weight of material =  100.000

     CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
     Cohesion - - - - - - - -       0.000
     Friction angle - - - - -  28.000 degrees

     Pore water pressures defined by piezometric line
     Number of the piezometric line used =  1
     Negative pore pressures set to zero

DATA FOR MATERIAL TYPE  5
FOUNDATION LAYER

     Unit weight of material =  130.000

     CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
     Cohesion - - - - - - - -       0.000
     Friction angle - - - - -  38.000 degrees

     Pore water pressures defined by piezometric line
     Number of the piezometric line used =  1
     Negative pore pressures set to zero

DATA FOR MATERIAL TYPE  6
SUB-FOUNDATION LAYER

     Unit weight of material =  135.000

     CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
     Cohesion - - - - - - - -    1000.000
     Friction angle - - - - -  30.000 degrees

     Pore water pressures defined by piezometric line
     Number of the piezometric line used =  1
     Negative pore pressures set to zero

All new material properties defined - No old data retained
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:   7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO.  4
*****************************
* NEW PIEZOMETRIC LINE DATA *
*****************************

Line
 No.    Point       X           Y

  1 - Unit weight of water =   62.40   DRAIN WORKING
  1        1   -5000.000     606.000   DRAIN WORKING
  1        2     206.000     606.000   DRAIN WORKING
  1        3     230.000     617.500   DRAIN WORKING
  1        4     293.000     629.000   DRAIN WORKING
  1        5     384.000     640.000   DRAIN WORKING
  1        6     416.000     652.000   DRAIN WORKING
  1        7     429.000     663.500   DRAIN WORKING
  1        8     448.000     675.000   DRAIN WORKING
  1        9     470.000     686.500   DRAIN WORKING
  1       10     498.000     698.000   DRAIN WORKING
  1       11     508.000     708.000   DRAIN WORKING
  1       12     512.000     721.000   DRAIN WORKING
  1       13    5000.000     721.000   DRAIN WORKING

All new piezometric lines defined - No old lines retained
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO. 24
********************************
* NEW REINFORCEMENT LINE DATA *
********************************

REINFORCEMENT LINE  1

Option = 1 - Forces applied in direction of reinforcement

     Point      X              Y             Force

       1       474.500       718.000    0.16000E+05
       2       494.500       718.000    0.00000E+00

REINFORCEMENT LINE  2

Option = 1 - Forces applied in direction of reinforcement

     Point      X              Y             Force

       1       474.500       721.000    0.12000E+05
       2       494.500       721.000    0.00000E+00

REINFORCEMENT LINE  3

Option = 1 - Forces applied in direction of reinforcement

     Point      X              Y             Force

       1       474.500       724.000    0.80000E+04
       2       494.500       724.000    0.00000E+00

REINFORCEMENT LINE  4

Option = 1 - Forces applied in direction of reinforcement

     Point      X              Y             Force

       1       474.500       727.000    0.40000E+04
       2       494.500       727.000    0.00000E+00

REINFORCEMENT LINE  5

Option = 1 - Forces applied in direction of reinforcement

     Point      X              Y             Force
```

```
          1        492.000        728.000   0.00000E+00
          2        512.000        728.000   0.40000E+04

REINFORCEMENT LINE  6

Option = 1 - Forces applied in direction of reinforcement

      Point       X               Y             Force

          1        492.000        725.000   0.00000E+00
          2        512.000        725.000   0.80000E+04

All new reinforcement lines defined - No old lines retained
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO.  9
**********************************
* NEW ANALYSIS/COMPUTATION DATA *
**********************************

Circular Shear Surface(s)

Automatic Search Performed

Starting Center Coordinate for Search at -
                                            X =      415.000
                                            Y =      790.000

Required accuracy for critical center (= minimum
spacing between grid points) =      2.000

Critical shear surface not allowed to pass below Y =     640.000

For the initial mode of search
all circles are tangent to horizontal line at -
                                            Y =      685.000

Initial trial estimate for the factor of safety =   1.500

Depth of crack =      2.000

Short form of output will be used for search

--------------------------------------------------------------------
THE FOLLOWING REPRESENT EITHER DEFAULT OR PREVIOUSLY DEFINED VALUES:

Initial trial estimate for side force inclination =  15.000 degrees
(Applicable to Spencer's procedure only)

Maximum number of iterations allowed for
calculating the factor of safety =   40

Allowed force imbalance for convergence =     100.000

Allowed moment imbalance for convergence =     100.000

Initial trial values for factor of safety (and side force inclination
for Spencer's procedure) will be kept constant during search

Maximum subtended angle to be used for subdivision of the
circle into slices =   3.00 degrees
```

```
Search will be continued to locate a more critical shear
surface (if one exists) after the initial mode is complete

Depth of water in crack =        0.000

Unit weight of water in crack =     62.400

Seismic coefficient = 0.000

Procedure used to compute the factor of safety: SPENCER
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO. 10
***************************
* NEW SLOPE GEOMETRY DATA *
***************************

NOTE - NO DATA WERE INPUT, SLOPE GEOMETRY DATA
WERE GENERATED BY THE PROGRAM

Slope Coordinates -

     Point        X            Y

        1   -5000.000     606.000
        2     206.000     606.000
        3     230.000     620.000
        4     313.000     641.000
        5     400.000     682.000
        6     410.000     682.000
        7     474.500     715.000
        8     474.500     730.000
        9     512.000     730.000
       10     512.000     722.000
       11     644.000     675.000
       12     796.000     637.000
       13     943.000     632.000
       14    5000.000     632.000
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO. 14
**************************************************************
* SHORT-FORM TABLE FOR SEARCH WITH CIRCULAR SHEAR SURFACES *
**************************************************************
                    Center Coordinates of
                       Critical Circle                Factor   Side
                                                        of     Force
Mode                           X          Y      Radius  Safety  Inclin.

 2  Tangent Line         415.000    790.000    105.000   1.496   21.64
    at Y =     685.0

 3  Constant Radius      413.000    788.000    105.000   1.495   23.00
    of R =     105.0

 2  Tangent Line         413.000    790.000    107.000   1.492   22.77
    at Y =     683.0

 3  Constant Radius      413.000    790.000    107.000   1.492   22.77
    of R =     107.0

TABLE NO. 15
***** FINAL CRITICAL CIRCLE INFORMATION *****
X Coordinate of Center - - - - - - -   413.000
Y Coordinate of Center - - - - - - -   790.000
Radius - - - - - - - - - - - - - - -   107.000
Factor of Safety - - - - - - - - - -     1.492
Side Force Inclination - - - - - - -     22.77

Number of circles tried  - - - - - -  137
No. of circles F calc. for - - - - -  104
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO. 20
*******************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)              *
*******************************************************************

Slice                     Slice   Matl.             Friction    Pore
  No.     X        Y      Weight  Type   Cohesion    Angle   Pressure

        412.0    683.0
   1    412.5    683.0        34.6   3       20.00    35.00        0.0
        413.0    683.0
   2    414.5    683.0       480.5   3       20.00    35.00        0.0
        416.0    683.0
   3    418.8    683.2      2312.1   3       20.00    35.00        0.0
        421.6    683.3
   4    424.4    683.6      3977.6   3       20.00    35.00        0.0
        427.2    683.9
   5    428.1    684.1      1647.8   3       20.00    35.00        0.0
        429.0    684.2
   6    431.8    684.7      5816.7   3       20.00    35.00        0.0
        434.5    685.2
   7    437.2    685.8      6900.7   3       20.00    35.00        0.0
        440.0    686.5
   8    442.7    687.2      7722.9   3       20.00    35.00        0.0
        445.4    688.0
   9    446.7    688.4      4075.0   3       20.00    35.00        0.0
        448.0    688.9
  10    450.6    689.9      8463.7   3       20.00    35.00        0.0
        453.2    690.9
  11    455.8    692.0      8637.6   3       20.00    35.00        0.0
        458.4    693.1
  12    460.9    694.4      8566.0   3       20.00    35.00        0.0
        463.4    695.6
  13    465.8    697.0      8263.1   3       20.00    35.00        0.0
        468.3    698.4
  14    469.1    698.9      2905.5   3       20.00    35.00        0.0
        470.0    699.4
  15    472.2    700.9      7259.5   3       20.00    35.00        0.0
        474.5    702.4
  16    476.6    704.0     13522.5   3       20.00    35.00        0.0
        478.7    705.5
  17    480.8    707.3     12297.7   2       20.00    35.00        0.0
        483.0    709.1
  18    485.1    711.0      9857.5   2       20.00    35.00        0.0
        487.1    712.8
  19    489.1    714.8      7464.6   2       20.00    35.00        0.0
```

	491.1	716.8					
20	492.9	718.9	5157.7	2	20.00	35.00	0.0
	494.8	721.0					
21	494.9	721.1	234.7	2	20.00	35.00	0.0
	495.0	721.3					

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO. 20
*******************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)              *
*******************************************************************

Slice                       Slice   Matl.            Friction    Pore
  No.      X        Y       Weight  Type    Cohesion   Angle   Pressure

        495.0    721.3
  22    495.2    721.5       393.0    2        20.00    35.00       0.0
        495.4    721.7
  23    495.5    721.9       248.5    1       200.00    32.50       0.0
        495.6    722.0
  24    496.8    723.5      1937.8    3        20.00    35.00       0.0
        498.0    725.0
  25    499.1    726.5       964.4    3        20.00    35.00       0.0
        500.2    728.0
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run:  10: 4:1990     Time of this run:   7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO. 21
*******************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)               *
*******************************************************************

                                      FORCES DUE TO SURFACE PRESSURES
                             Y for
Slice            Seismic    Seismic     Normal   Shear
  No.     X       Force      Force      Force    Force        X        Y

   1    412.5       0.        683.1       0.       0.        0.0      0.0
   2    414.5       0.        683.7       0.       0.        0.0      0.0
   3    418.8       0.        684.8       0.       0.        0.0      0.0
   4    424.4       0.        686.5       0.       0.        0.0      0.0
   5    428.1       0.        687.7       0.       0.        0.0      0.0
   6    431.8       0.        688.9       0.       0.        0.0      0.0
   7    437.2       0.        690.9       0.       0.        0.0      0.0
   8    442.7       0.        693.0       0.       0.        0.0      0.0
   9    446.7       0.        694.6       0.       0.        0.0      0.0
  10    450.6       0.        696.3       0.       0.        0.0      0.0
  11    455.8       0.        698.7       0.       0.        0.0      0.0
  12    460.9       0.        701.2       0.       0.        0.0      0.0
  13    465.8       0.        703.8       0.       0.        0.0      0.0
  14    469.1       0.        705.6       0.       0.        0.0      0.0
  15    472.2       0.        707.4       0.       0.        0.0      0.0
  16    476.6       0.        717.0       0.       0.        0.0      0.0
  17    480.8       0.        718.6       0.       0.        0.0      0.0
  18    485.1       0.        720.5       0.       0.        0.0      0.0
  19    489.1       0.        722.4       0.       0.        0.0      0.0
  20    492.9       0.        724.5       0.       0.        0.0      0.0
  21    494.9       0.        725.6       0.       0.        0.0      0.0
  22    495.2       0.        725.7       0.       0.        0.0      0.0
  23    495.5       0.        725.9       0.       0.        0.0      0.0
  24    496.8       0.        726.8       0.       0.        0.0      0.0
  25    499.1       0.        728.3       0.       0.        0.0      0.0
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO. 22
****************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)              *
****************************************************************

        INTERNAL FORCES DUE TO SOIL REINFORCEMENT

                                      Moment about
Slice  Horizontal     Vertical      Center of     Resultant    Angle
 No.      Force         Force       Slice Base      Force     (degs.)

   1   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
   2   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
   3   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
   4   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
   5   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
   6   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
   7   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
   8   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
   9   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  10   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  11   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  12   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  13   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  14   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  15   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  16   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  17   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  18   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  19   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  20   0.1911E+04   0.0000E+00   0.1751E+04   0.1911E+04      0.00
  21   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  22   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  23   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00      0.00
  24   0.2398E+04   0.0000E+00  -0.3587E+04   0.2398E+04      0.00
  25   0.1641E+04   0.0000E+00  -0.2456E+04   0.1641E+04      0.00
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO. 23
******************************************************************
* INFORMATION GENERATED DURING ITERATIVE SOLUTION FOR THE FACTOR *
* OF SAFETY AND SIDE FORCE INCLINATION BY SPENCER'S PROCEDURE    *
******************************************************************

        Trial     Trial
       Factor   Side Force    Force      Moment               Delta
Iter-    of    Inclination  Imbalance  Imbalance   Delta-F    Theta
ation  Safety   (degrees)     (lbs.)   (ft.-lbs.)           (degrees)

   1   1.50000     15.0000  0.1065E+04 -0.6590E+06
First-order corrections to F and THETA ......... -0.209E-01 0.342E+01
Second-order correction - Iteration   1 ........ -0.201E-01 0.342E+01
Second-order correction - Iteration   2 ........ -0.201E-01 0.342E+01

   2   1.47989     18.4199 -0.3909E+01 -0.3717E+05
First-order corrections to F and THETA .........  0.122E-01 0.455E+01
Second-order correction - Iteration   1 ........  0.127E-01 0.455E+01
Second-order correction - Iteration   2 ........  0.127E-01 0.455E+01

   3   1.49261     22.9713 -0.2143E+01  0.2927E+04
First-order corrections to F and THETA ......... -0.546E-03-0.206E+00
Second-order correction - Iteration   1 ........ -0.544E-03-0.206E+00

   4   1.49207     22.7658 -0.1953E-02 -0.2273E+01
First-order corrections to F and THETA .........  0.104E-05 0.338E-03

FACTOR OF SAFETY - - - - - - - -     1.492
SIDE FORCE INCLINATION - - - - -     22.77
NUMBER OF ITERATIONS - - - - - -     4
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO. 24
***********************************************
* FINAL RESULTS FOR SHEAR SURFACE (CRITICAL *
* SURFACE IN CASE OF A SEARCH)               *
***********************************************

SPENCER'S PROCEDURE USED TO COMPUTE FACTOR OF SAFETY
Factor of Safety =  1.492     Side Force Inclination =  22.77 Degrees

      -------- VALUES AT CENTER OF BASE OF SLICE---------

                                   Total    Effective
Slice                              Normal    Normal      Shear
  No.   X-center  Y-center         Stress    Stress      Stress

   1       412.5      683.0         49.0       49.0        36.4
   2       414.5      683.0        203.1      203.1       108.7
   3       418.8      683.2        491.3      491.3       244.0
   4       424.4      683.6        799.7      799.7       388.7
   5       428.1      684.1        969.3      969.3       468.3
   6       431.8      684.7       1100.4     1100.4       529.8
   7       437.2      685.8       1254.8     1254.8       602.3
   8       442.7      687.2       1355.8     1355.8       649.7
   9       446.7      688.4       1403.5     1403.5       672.0
  10       450.6      689.9       1420.0     1420.0       679.8
  11       455.8      692.0       1412.2     1412.2       676.1
  12       460.9      694.4       1369.3     1369.3       656.0
  13       465.8      697.0       1295.5     1295.5       621.4
  14       469.1      698.9       1232.7     1232.7       591.9
  15       472.2      700.9       1154.5     1154.5       555.2
  16       476.6      704.0       2225.0     2225.0      1057.6
  17       480.8      707.3       1849.6     1849.6       881.4
  18       485.1      711.0       1471.7     1471.7       704.1
  19       489.1      714.8       1108.8     1108.8       533.7
  20       492.9      718.9        882.8      882.8       427.7
  21       494.9      721.1        590.1      590.1       290.3
  22       495.2      721.5        563.5      563.5       277.9
  23       495.5      721.9        494.0      494.0       345.0
  24       496.8      723.5        635.5      635.5       311.6
  25       499.1      726.5        366.7      366.7       185.5


CHECK SUMS - (ALL SHOULD BE SMALL)
SUM OF FORCES IN VERTICAL DIRECTION     =         0.00  (= 0.346E-02)
     SHOULD NOT EXCEED    0.100E+03
SUM OF FORCES IN HORIZONTAL DIRECTION   =         0.00  (= 0.446E-02)
     SHOULD NOT EXCEED    0.100E+03
```

```
SUM OF MOMENTS ABOUT COORDINATE ORIGIN =         3.31  (= 0.331E+01)
     SHOULD NOT EXCEED    0.100E+03
SHEAR STRENGTH/SHEAR FORCE CHECK-SUM   =         0.00  (= 0.239E-02)
     SHOULD NOT EXCEED    0.100E+03
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
UPPER CIRCLE SEARCH

TABLE NO. 25
**********************************************
* FINAL RESULTS FOR SHEAR SURFACE (CRITICAL *
* SURFACE IN CASE OF A SEARCH)              *
**********************************************

SPENCER'S PROCEDURE USED TO COMPUTE FACTOR OF SAFETY
Factor of Safety =  1.492     Side Force Inclination =  22.77 Degrees

       --------------- VALUES AT RIGHT SIDE OF SLICE ---------------

                            Y-Coord. of   Fraction    Sigma      Sigma
Slice                 Side  Side Force       of         at         at
 No.      X-Right    Force   Location      Height      Top      Bottom

   1       413.0       41.       683.2     0.411       33.0      108.8
   2       416.0      386.       683.7     0.344       10.9      339.8
   3       421.6     1704.       684.8     0.308      -52.8      737.9
   4       427.2     3535.       685.9     0.288     -129.4     1082.5
   5       429.0     4193.       686.3     0.283     -154.1     1182.6
   6       434.5     6189.       687.7     0.274     -218.4     1438.2
   7       440.0     8025.       689.3     0.265     -280.7     1641.1
   8       445.4     9533.       691.1     0.254     -344.9     1800.3
   9       448.0    10126.       692.0     0.248     -379.1     1866.4
  10       453.2    10958.       694.0     0.234     -454.3     1977.4
  11       458.4    11288.       696.0     0.214     -544.4     2069.2
  12       463.4    11128.       698.2     0.187     -658.4     2155.5
  13       468.3    10524.       700.3     0.146     -811.1     2255.8
  14       470.0    10207.       701.1     0.127     -881.1     2301.6
  15       474.5     9168.       703.1     0.036     -772.8     1638.6
  16       478.7     6522.       704.9     BELOW     -528.2     1019.4
  17       483.0     3538.       705.5     BELOW     -472.3      784.0
  18       487.1      676.       687.6     BELOW     -392.3      464.9
  19       491.1    -1838.       725.3     0.647     -241.9      -15.3
  20       494.8    -2047.       727.1     0.678     -433.6       13.8
  21       495.0    -2141.       726.9     0.648     -426.7      -25.1
  22       495.4    -2301.       726.7     0.602     -412.1      -99.4
  23       495.6    -2368.       726.7     0.583     -408.3     -137.5
  24       498.0    -1034.       728.6     0.723     -447.0       65.1
  25       500.2        0.     -3080.0     BELOW       -3.9        3.9

CHECK SUMS - (ALL SHOULD BE SMALL)
SUM OF FORCES IN VERTICAL DIRECTION    =          0.00  (= 0.346E-02)
     SHOULD NOT EXCEED    0.100E+03
SUM OF FORCES IN HORIZONTAL DIRECTION  =          0.00  (= 0.446E-02)
     SHOULD NOT EXCEED    0.100E+03
```

```
SUM OF MOMENTS ABOUT COORDINATE ORIGIN =         3.31  (= 0.331E+01)
     SHOULD NOT EXCEED    0.100E+03
SHEAR STRENGTH/SHEAR FORCE CHECK-SUM   =         0.00  (= 0.239E-02)
     SHOULD NOT EXCEED    0.100E+03

***** CAUTION ***** FORCES BETWEEN SLICES ARE NEGATIVE AT POINTS
                    ALONG THE UPPER ONE-HALF OF THE SHEAR SURFACE -
                    A TENSION CRACK MAY BE NEEDED.

***** CAUTION ***** SOME OF THE FORCES BETWEEN SLICES ACT AT POINTS
                    ABOVE THE SURFACE OF THE SLOPE OR BELOW THE
                    SHEAR SURFACE - EITHER A TENSION CRACK MAY BE
                    NEEDED OR THE SOLUTION MAY NOT BE A VALID SOLUTION.
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
LOWER CIRCLE SEARCH

TABLE NO.  9
*********************************
* NEW ANALYSIS/COMPUTATION DATA *
*********************************

Circular Shear Surface(s)

Automatic Search Performed

Starting Center Coordinate for Search at -
                                              X =     310.000
                                              Y =     890.000

Required accuracy for critical center (= minimum
spacing between grid points) =       2.000

Critical shear surface not allowed to pass below Y =      590.000

For the initial mode of search
all circles are tangent to horizontal line at -
                                              Y =     615.000

Initial trial estimate for the factor of safety =    1.500

Depth of crack =       5.000

----------------------------------------------------------------------
THE FOLLOWING REPRESENT EITHER DEFAULT OR PREVIOUSLY DEFINED VALUES:

Initial trial estimate for side force inclination =  15.000 degrees
(Applicable to Spencer´s procedure only)

Maximum number of iterations allowed for
calculating the factor of safety =   40

Allowed force imbalance for convergence =      100.000

Allowed moment imbalance for convergence =     100.000

Initial trial values for factor of safety (and side force inclination
for Spencer´s procedure) will be kept constant during search

Short form of output will be used for search

Maximum subtended angle to be used for subdivision of the
circle into slices =   3.00 degrees
```

```
Search will be continued to locate a more critical shear
surface (if one exists) after the initial mode is complete

Depth of water in crack =       0.000

Unit weight of water in crack =    62.400

Seismic coefficient = 0.000

Procedure used to compute the factor of safety: SPENCER
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
LOWER CIRCLE SEARCH

TABLE NO. 14
************************************************************
* SHORT-FORM TABLE FOR SEARCH WITH CIRCULAR SHEAR SURFACES *
************************************************************
                   Center Coordinates of
                      Critical Circle                 Factor   Side
                                                       of      Force
Mode                       X          Y       Radius  Safety  Inclin.

 2  Tangent Line        310.000    892.000    277.000    1.548    19.16
    at Y =    615.0

 3  Constant Radius     310.000    892.000    277.000    1.548    19.16
    of R =    277.0

TABLE NO. 15
***** FINAL CRITICAL CIRCLE INFORMATION *****
X Coordinate of Center - - - - - - - -   310.000
Y Coordinate of Center - - - - - - - -   892.000
Radius - - - - - - - - - - - - - - - -   277.000
Factor of Safety - - - - - - - - - - -     1.548
Side Force Inclination - - - - - - - -     19.16

Number of circles tried  - - - - - - -   68
No. of circles F calc. for - - - - - -   61
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990      Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
LOWER CIRCLE SEARCH

TABLE NO. 20
*****************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)              *
*****************************************************************

Slice                         Slice    Matl.              Friction    Pore
 No.      X          Y        Weight   Type    Cohesion    Angle    Pressure

        242.9      623.3
   1    247.0      622.3      2038.1    3        20.00     35.00        0.0
        251.1      621.3
   2    258.2      620.0     12719.9    3        20.00     35.00      165.8
        265.3      618.6
   3    272.5      617.6     23532.1    3        20.00     35.00      474.7
        279.7      616.7
   4    286.3      616.1     30255.4    3        20.00     35.00      729.4
        293.0      615.5
   5    300.2      615.3     40773.4    3        20.00     35.00      911.6
        307.5      615.0
   6    308.7      615.0      7808.6    3        20.00     35.00      992.0
        310.0      615.0
   7    311.5      615.0      9604.6    3        20.00     35.00     1012.6
        313.0      615.0
   8    320.2      615.3     52769.8    3        20.00     35.00     1061.4
        327.5      615.6
   9    334.7      616.2     63252.9    3        20.00     35.00     1113.4
        341.9      616.8
  10    349.1      617.9     72048.9    3        20.00     35.00     1117.7
        356.3      618.9
  11    363.4      620.3     79083.9    3        20.00     35.00     1074.3
        370.5      621.7
  12    376.3      623.1     68442.3    3        20.00     35.00      995.8
        382.0      624.5
  13    383.0      624.8     12298.6    3        20.00     35.00      941.3
        384.0      625.1
  14    390.9      627.2     87617.4    3        20.00     35.00      961.8
        397.9      629.3
  15    398.9      629.7     13808.0    3        20.00     35.00      994.2
        400.0      630.0
  16    403.0      631.1     37738.0    3        20.00     35.00     1000.1
        405.9      632.1
  17    408.0      632.9     24976.8    2        20.00     35.00     1003.1
        410.0      633.7
  18    413.0      634.9     36489.5    2        20.00     35.00      998.0
        416.0      636.1
  19    422.5      639.0     80309.7    2        20.00     35.00     1171.6
```

	429.0	641.9					
20	435.5	645.1	80604.0	2	20.00	35.00	1389.2
	441.9	648.4					
21	445.0	650.1	37767.5	2	20.00	35.00	1437.3
	448.0	651.8					

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
LOWER CIRCLE SEARCH

TABLE NO. 20
******************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)              *
******************************************************************

Slice                     Slice   Matl.            Friction    Pore
  No.     X        Y      Weight  Type   Cohesion    Angle   Pressure

        448.0    651.8
  22    454.2    655.6    75848.1    2      20.00    35.00     1412.6
        460.4    659.4
  23    465.2    662.6    57244.4    2      20.00    35.00     1332.7
        470.0    665.9
  24    472.2    667.5    26066.2    2      20.00    35.00     1242.7
        474.5    669.1
  25    480.2    673.6    80651.6    2      20.00    35.00     1067.3
        485.9    678.0
  26    490.5    681.9    54434.8    2      20.00    35.00      809.0
        495.0    685.8
  27    496.5    687.2    16031.6    2      20.00    35.00      635.4
        498.0    688.6
  28    502.0    692.4    37361.1    2      20.00    35.00      598.1
        506.0    696.3
  29    507.0    697.3     8085.3    2      20.00    35.00      606.9
        508.0    698.3
  30    510.0    700.4    14573.2    2      20.00    35.00      881.5
        512.0    702.5
  31    513.6    704.2     6579.9    2      20.00    35.00     1050.2
        515.2    705.9
  32    518.5    709.7     8001.4    1     200.00    32.50      705.7
        521.8    713.5
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
LOWER CIRCLE SEARCH

TABLE NO. 21
*********************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)             *
*********************************************************************

                                           FORCES DUE TO SURFACE PRESSURES
                             Y for
Slice              Seismic  Seismic    Normal   Shear
 No.        X       Force    Force      Force    Force        X         Y

  1      247.0       0.       623.3      0.       0.        0.0       0.0
  2      258.2       0.       623.6      0.       0.        0.0       0.0
  3      272.5       0.       624.2      0.       0.        0.0       0.0
  4      286.3       0.       625.2      0.       0.        0.0       0.0
  5      300.2       0.       626.5      0.       0.        0.0       0.0
  6      308.7       0.       627.5      0.       0.        0.0       0.0
  7      311.5       0.       627.8      0.       0.        0.0       0.0
  8      320.2       0.       629.8      0.       0.        0.0       0.0
  9      334.7       0.       633.7      0.       0.        0.0       0.0
 10      349.1       0.       637.9      0.       0.        0.0       0.0
 11      363.4       0.       642.5      0.       0.        0.0       0.0
 12      376.3       0.       647.0      0.       0.        0.0       0.0
 13      383.0       0.       649.4      0.       0.        0.0       0.0
 14      390.9       0.       652.5      0.       0.        0.0       0.0
 15      398.9       0.       655.6      0.       0.        0.0       0.0
 16      403.0       0.       656.5      0.       0.        0.0       0.0
 17      408.0       0.       657.5      0.       0.        0.0       0.0
 18      413.0       0.       659.2      0.       0.        0.0       0.0
 19      422.5       0.       663.7      0.       0.        0.0       0.0
 20      435.5       0.       670.1      0.       0.        0.0       0.0
 21      445.0       0.       675.0      0.       0.        0.0       0.0
 22      454.2       0.       680.1      0.       0.        0.0       0.0
 23      465.2       0.       686.4      0.       0.        0.0       0.0
 24      472.2       0.       690.7      0.       0.        0.0       0.0
 25      480.2       0.       701.8      0.       0.        0.0       0.0
 26      490.5       0.       706.0      0.       0.        0.0       0.0
 27      496.5       0.       708.6      0.       0.        0.0       0.0
 28      502.0       0.       711.2      0.       0.        0.0       0.0
 29      507.0       0.       713.6      0.       0.        0.0       0.0
 30      510.0       0.       715.2      0.       0.        0.0       0.0
 31      513.6       0.       712.8      0.       0.        0.0       0.0
 32      518.5       0.       714.7      0.       0.        0.0       0.0
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run:  10: 4:1990     Time of this run:   7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
LOWER CIRCLE SEARCH

TABLE NO. 22
*******************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)               *
*******************************************************************

        INTERNAL FORCES DUE TO SOIL REINFORCEMENT

                                     Moment about
Slice   Horizontal      Vertical      Center of     Resultant      Angle
 No.      Force           Force       Slice Base      Force       (degs.)

   1    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
   2    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
   3    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
   4    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
   5    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
   6    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
   7    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
   8    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
   9    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  10    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  11    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  12    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  13    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  14    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  15    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  16    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  17    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  18    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  19    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  20    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  21    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  22    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  23    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  24    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  25    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  26    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  27    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  28    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  29    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  30    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  31    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
  32    0.0000E+00     0.0000E+00    0.0000E+00    0.0000E+00       0.00
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
LOWER CIRCLE SEARCH

TABLE NO. 23
*******************************************************************
* INFORMATION GENERATED DURING ITERATIVE SOLUTION FOR THE FACTOR *
* OF SAFETY AND SIDE FORCE INCLINATION BY SPENCER'S PROCEDURE    *
*******************************************************************

        Trial     Trial
        Factor   Side Force    Force       Moment               Delta
Iter-    of     Inclination  Imbalance   Imbalance    Delta-F    Theta
ation  Safety    (degrees)     (lbs.)    (ft.-lbs.)            (degrees)

   1    1.50000     15.0000 -0.5435E+04  0.8978E+06
First-order corrections to F and THETA .........  0.511E-01 0.488E+01
Second-order correction - Iteration   1 ........  0.531E-01 0.488E+01
Second-order correction - Iteration   2 ........  0.531E-01 0.488E+01

   2    1.55313     19.8804 -0.2518E+02  0.3518E+06
First-order corrections to F and THETA ......... -0.531E-02-0.711E+00
Second-order correction - Iteration   1 ........ -0.526E-02-0.711E+00
Second-order correction - Iteration   2 ........ -0.526E-02-0.711E+00

   3    1.54787     19.1692  0.2246E+00  0.1945E+04
First-order corrections to F and THETA ......... -0.331E-04-0.434E-02
Second-order correction - Iteration   1 ........ -0.331E-04-0.434E-02

   4    1.54784     19.1648  0.3467E-01  0.7308E+01
First-order corrections to F and THETA ......... -0.492E-06-0.503E-04

FACTOR OF SAFETY - - - - - - - - -       1.548
SIDE FORCE INCLINATION - - - - -         19.16
NUMBER OF ITERATIONS - - - - - -         4
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990      Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
LOWER CIRCLE SEARCH

TABLE NO. 24
*********************************************
* FINAL RESULTS FOR SHEAR SURFACE (CRITICAL *
* SURFACE IN CASE OF A SEARCH)              *
*********************************************

SPENCER´S PROCEDURE USED TO COMPUTE FACTOR OF SAFETY
Factor of Safety =  1.548     Side Force Inclination =  19.16 Degrees

       -------- VALUES AT CENTER OF BASE OF SLICE---------

                                      Total    Effective
Slice                                 Normal    Normal         Shear
  No.    X-center   Y-center          Stress    Stress         Stress

   1       247.0      622.3          391.1      391.1         189.9
   2       258.2      620.0         1244.9     1079.1         501.1
   3       272.5      617.6         2099.8     1625.1         748.1
   4       286.3      616.1         2754.7     2025.3         929.1
   5       300.2      615.3         3266.0     2354.3        1078.0
   6       308.7      615.0         3528.9     2536.9        1160.6
   7       311.5      615.0         3599.6     2587.0        1183.2
   8       320.2      615.3         4007.6     2946.2        1345.7
   9       334.7      616.2         4650.4     3537.0        1613.0
  10       349.1      617.9         5139.0     4021.3        1832.1
  11       363.4      620.3         5486.1     4411.8        2008.7
  12       376.3      623.1         5691.9     4696.1        2137.3
  13       383.0      624.8         5765.1     4823.8        2195.1
  14       390.9      627.2         5794.3     4832.5        2199.0
  15       398.9      629.7         5812.6     4818.4        2192.7
  16       403.0      631.1         5646.6     4646.5        2114.9
  17       408.0      632.9         5369.7     4366.6        1988.3
  18       413.0      634.9         5248.2     4250.3        1935.6
  19       422.5      639.0         5196.6     4025.0        1833.8
  20       435.5      645.1         5069.6     3680.4        1677.9
  21       445.0      650.1         4928.9     3491.6        1592.5
  22       454.2      655.6         4727.3     3314.8        1512.4
  23       465.2      662.6         4440.2     3107.5        1418.7
  24       472.2      667.5         4221.6     2978.9        1360.5
  25       480.2      673.6         4947.4     3880.0        1768.2
  26       490.5      681.9         4044.2     3235.3        1476.5
  27       496.5      687.2         3499.5     2864.1        1308.6
  28       502.0      692.4         2994.8     2396.6        1097.1
  29       507.0      697.3         2552.2     1945.4         893.0
  30       510.0      700.4         2331.8     1450.3         669.0
  31       513.6      704.2         1419.8      369.5         180.1
  32       518.5      709.7          770.0       64.3         155.7
```

```
CHECK SUMS - (ALL SHOULD BE SMALL)
SUM OF FORCES IN VERTICAL DIRECTION     =          0.05   (= 0.529E-01)
     SHOULD NOT EXCEED    0.100E+03
SUM OF FORCES IN HORIZONTAL DIRECTION   =          0.07   (= 0.706E-01)
     SHOULD NOT EXCEED    0.100E+03
SUM OF MOMENTS ABOUT COORDINATE ORIGIN =         -2.09   (=-0.209E+01)
     SHOULD NOT EXCEED    0.100E+03
SHEAR STRENGTH/SHEAR FORCE CHECK-SUM    =          0.02   (= 0.191E-01)
     SHOULD NOT EXCEED    0.100E+03
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990      Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN WORKING
LOWER CIRCLE SEARCH

TABLE NO. 25
**********************************************
* FINAL RESULTS FOR SHEAR SURFACE (CRITICAL *
* SURFACE IN CASE OF A SEARCH)              *
**********************************************

SPENCER'S PROCEDURE USED TO COMPUTE FACTOR OF SAFETY
Factor of Safety =  1.548     Side Force Inclination =  19.16 Degrees

       --------------- VALUES AT RIGHT SIDE OF SLICE ---------------

                           Y-Coord. of   Fraction    Sigma      Sigma
Slice                Side  Side Force       of         at         at
 No.     X-Right    Force   Location     Height      Top       Bottom

   1      251.1     2437.       623.7     0.597     914.6      241.2
   2      265.3    13571.       623.6     0.480    1097.1     1391.5
   3      279.7    29318.       624.0     0.464    1366.3     2116.7
   4      293.0    45762.       625.0     0.464    1654.9     2579.3
   5      307.5    64068.       626.5     0.468    1991.7     2929.4
   6      310.0    67191.       626.8     0.469    2050.0     2978.9
   7      313.0    70887.       627.2     0.457    1849.8     3151.8
   8      327.5    89256.       629.3     0.426    1450.7     3773.5
   9      341.9   107549.       631.7     0.392     947.9     4428.7
  10      356.3   124250.       634.5     0.366     545.7     4976.4
  11      370.5   138265.       637.7     0.345     203.2     5424.3
  12      382.0   147193.       640.7     0.330     -51.6     5726.9
  13      384.0   148506.       641.3     0.328     -95.1     5775.1
  14      397.9   154792.       645.4     0.311    -370.7     6028.1
  15      400.0   155293.       646.1     0.313    -342.8     6064.6
  16      405.9   155940.       648.1     0.320    -238.6     6147.1
  17      410.0   155758.       649.5     0.323    -190.4     6184.9
  18      416.0   154699.       651.7     0.319    -254.6     6220.6
  19      429.0   148138.       656.9     0.302    -535.2     6148.4
  20      441.9   135836.       662.7     0.285    -744.9     5887.4
  21      448.0   128392.       665.6     0.277    -829.3     5717.6
  22      460.4   110423.       671.8     0.257    -982.5     5292.4
  23      470.0    94277.       677.0     0.238   -1085.4     4889.8
  24      474.5    86223.       679.6     0.201   -1246.8     4385.2
  25      485.9    60943.       686.8     0.169   -1091.3     3307.5
  26      495.0    41774.       693.0     0.161    -922.3     2709.2
  27      498.0    35809.       695.0     0.156    -866.7     2499.5
  28      506.0    20701.       700.8     0.133    -695.4     1854.6
  29      508.0    17125.       702.3     0.125    -636.9     1657.0
  30      512.0     9652.       705.6     0.137    -462.0     1246.0
  31      515.2     5117.       708.5     0.177    -302.2      946.7
  32      521.8        0.       408.8     BELOW       1.8       -1.8
```

```
CHECK SUMS - (ALL SHOULD BE SMALL)
SUM OF FORCES IN VERTICAL DIRECTION      =         0.05  (= 0.529E-01)
     SHOULD NOT EXCEED    0.100E+03
SUM OF FORCES IN HORIZONTAL DIRECTION  =         0.07  (= 0.706E-01)
     SHOULD NOT EXCEED    0.100E+03
SUM OF MOMENTS ABOUT COORDINATE ORIGIN =        -2.09  (=-0.209E+01)
     SHOULD NOT EXCEED    0.100E+03
SHEAR STRENGTH/SHEAR FORCE CHECK-SUM    =         0.02  (= 0.191E-01)
     SHOULD NOT EXCEED    0.100E+03
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
UPPER CIRCLE SEARCH

TABLE NO.  4
******************************
* NEW PIEZOMETRIC LINE DATA *
******************************

Line
 No.    Point       X           Y

  1 - Unit weight of water =   62.40   DRAIN FAILED
  1        1   -5000.000     606.000   DRAIN FAILED
  1        2     206.000     606.000   DRAIN FAILED
  1        3     230.000     617.500   DRAIN FAILED
  1        4     290.000     629.000   DRAIN FAILED
  1        5     385.000     640.000   DRAIN FAILED
  1        6     444.000     675.000   DRAIN FAILED
  1        7     508.000     710.000   DRAIN FAILED
  1        8     511.900     721.000   DRAIN FAILED
  1        9    5000.000     721.000   DRAIN FAILED

All new piezometric lines defined - No old lines retained
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990    Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
UPPER CIRCLE SEARCH

TABLE NO.  9
*********************************
* NEW ANALYSIS/COMPUTATION DATA *
*********************************

Circular Shear Surface(s)

Automatic Search Performed

Starting Center Coordinate for Search at -
                                            X =     415.000
                                            Y =     790.000

Required accuracy for critical center (= minimum
spacing between grid points) =       2.000

Critical shear surface not allowed to pass below Y =     640.000

For the initial mode of search
all circles are tangent to horizontal line at -
                                            Y =     685.000

Initial trial estimate for the factor of safety =   1.500

Depth of crack =       2.000

--------------------------------------------------------------------
THE FOLLOWING REPRESENT EITHER DEFAULT OR PREVIOUSLY DEFINED VALUES:

Initial trial estimate for side force inclination =  15.000 degrees
(Applicable to Spencer's procedure only)

Maximum number of iterations allowed for
calculating the factor of safety =   40

Allowed force imbalance for convergence =     100.000

Allowed moment imbalance for convergence =     100.000

Initial trial values for factor of safety (and side force inclination
for Spencer's procedure) will be kept constant during search

Short form of output will be used for search

Maximum subtended angle to be used for subdivision of the
circle into slices =   3.00 degrees
```

```
Search will be continued to locate a more critical shear
surface (if one exists) after the initial mode is complete

Depth of water in crack =        0.000

Unit weight of water in crack =    62.400

Seismic coefficient = 0.000

Procedure used to compute the factor of safety: SPENCER
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
UPPER CIRCLE SEARCH

TABLE NO. 14
*************************************************************
* SHORT-FORM TABLE FOR SEARCH WITH CIRCULAR SHEAR SURFACES *
*************************************************************
                   Center Coordinates of
                      Critical Circle                 Factor    Side
                                                        of      Force
Mode                         X          Y      Radius  Safety  Inclin.

 2  Tangent Line          415.000    790.000    105.000   1.496   21.73
    at Y =      685.0

 3  Constant Radius       413.000    788.000    105.000   1.495   23.04
    of R =      105.0

 2  Tangent Line          413.000    790.000    107.000   1.492   22.93
    at Y =      683.0

 3  Constant Radius       413.000    790.000    107.000   1.492   22.93
    of R =      107.0

TABLE NO. 15
***** FINAL CRITICAL CIRCLE INFORMATION *****
X Coordinate of Center - - - - - - - -   413.000
Y Coordinate of Center - - - - - - - -   790.000
Radius - - - - - - - - - - - - - - - -   107.000
Factor of Safety - - - - - - - - - - -     1.492
Side Force Inclination - - - - - - - -    22.93

Number of circles tried  - - - - - -  137
No. of circles F calc. for - - - - -  105
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
UPPER CIRCLE SEARCH

TABLE NO. 20
*****************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)              *
*****************************************************************

Slice                        Slice   Matl.            Friction    Pore
 No.      X        Y         Weight  Type   Cohesion    Angle    Pressure

        412.0    683.0
  1     412.5    683.0        34.6    3      20.00      35.00        0.0
        413.0    683.0
  2     415.8    683.1      1325.8    3      20.00      35.00        0.0
        418.6    683.1
  3     421.4    683.4      3114.9    3      20.00      35.00        0.0
        424.2    683.6
  4     427.0    684.0      4669.6    3      20.00      35.00        0.0
        429.7    684.3
  5     432.5    684.8      5976.3    3      20.00      35.00        0.0
        435.2    685.3
  6     438.0    686.0      7025.5    3      20.00      35.00        0.0
        440.7    686.6
  7     442.3    687.1      4724.8    3      20.00      35.00        0.0
        444.0    687.6
  8     446.7    688.5      8165.4    3      20.00      35.00        0.0
        449.3    689.4
  9     451.9    690.4      8530.7    3      20.00      35.00        0.0
        454.5    691.4
 10     457.1    692.5      8642.3    3      20.00      35.00        0.0
        459.6    693.7
 11     462.1    695.0      8511.4    3      20.00      35.00        0.0
        464.6    696.3
 12     467.0    697.7      8153.7    3      20.00      35.00        0.0
        469.4    699.1
 13     471.8    700.6      7588.3    3      20.00      35.00        0.0
        474.1    702.2
 14     474.3    702.3       583.3    3      20.00      35.00        0.0
        474.5    702.4
 15     476.6    704.0     13522.5    3      20.00      35.00        0.0
        478.7    705.5
 16     480.8    707.3     12297.7    2      20.00      35.00        0.0
        483.0    709.1
 17     485.1    711.0      9857.5    2      20.00      35.00        0.0
        487.1    712.8
 18     489.1    714.8      7464.6    2      20.00      35.00        0.0
        491.1    716.8
 19     492.9    718.9      5157.7    2      20.00      35.00        0.0
```

```
        494.8     721.0
  20    494.9     721.1      234.7    2       20.00    35.00          0.0
        495.0     721.3
  21    495.2     721.5      393.0    2       20.00    35.00          0.0
        495.4     721.7
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
UPPER CIRCLE SEARCH

TABLE NO. 20
*******************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)               *
*******************************************************************

Slice                        Slice   Matl.              Friction     Pore
  No.      X        Y        Weight  Type    Cohesion    Angle     Pressure

         495.4    721.7
  22     495.5    721.9       248.5    1      200.00     32.50         0.0
         495.6    722.0
  23     497.3    724.2      2494.4    3       20.00     35.00         0.0
         499.1    726.4
  24     499.6    727.2       400.4    3       20.00     35.00         0.0
         500.2    728.0
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
UPPER CIRCLE SEARCH

TABLE NO. 21
*******************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)               *
*******************************************************************

                                          FORCES DUE TO SURFACE PRESSURES
                              Y for
Slice           Seismic     Seismic     Normal     Shear
 No.       X     Force       Force      Force      Force        X        Y

   1    412.5       0.       683.1        0.         0.        0.0      0.0
   2    415.8       0.       684.0        0.         0.        0.0      0.0
   3    421.4       0.       685.6        0.         0.        0.0      0.0
   4    427.0       0.       687.3        0.         0.        0.0      0.0
   5    432.5       0.       689.2        0.         0.        0.0      0.0
   6    438.0       0.       691.2        0.         0.        0.0      0.0
   7    442.3       0.       692.8        0.         0.        0.0      0.0
   8    446.7       0.       694.6        0.         0.        0.0      0.0
   9    451.9       0.       696.9        0.         0.        0.0      0.0
  10    457.1       0.       699.3        0.         0.        0.0      0.0
  11    462.1       0.       701.8        0.         0.        0.0      0.0
  12    467.0       0.       704.4        0.         0.        0.0      0.0
  13    471.8       0.       707.1        0.         0.        0.0      0.0
  14    474.3       0.       708.6        0.         0.        0.0      0.0
  15    476.6       0.       717.0        0.         0.        0.0      0.0
  16    480.8       0.       718.6        0.         0.        0.0      0.0
  17    485.1       0.       720.5        0.         0.        0.0      0.0
  18    489.1       0.       722.4        0.         0.        0.0      0.0
  19    492.9       0.       724.5        0.         0.        0.0      0.0
  20    494.9       0.       725.6        0.         0.        0.0      0.0
  21    495.2       0.       725.7        0.         0.        0.0      0.0
  22    495.5       0.       725.9        0.         0.        0.0      0.0
  23    497.3       0.       727.1        0.         0.        0.0      0.0
  24    499.6       0.       728.6        0.         0.        0.0      0.0
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run:  10: 4:1990     Time of this run:   7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
UPPER CIRCLE SEARCH

TABLE NO. 22
****************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)              *
****************************************************************

        INTERNAL FORCES DUE TO SOIL REINFORCEMENT

                                      Moment about
Slice   Horizontal    Vertical        Center of      Resultant     Angle
 No.      Force         Force        Slice Base        Force      (degs.)

   1   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   2   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   3   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   4   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   5   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   6   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   7   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   8   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   9   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  10   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  11   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  12   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  13   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  14   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  15   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  16   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  17   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  18   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  19   0.1911E+04   0.0000E+00    0.1751E+04   0.1911E+04     0.00
  20   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  21   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  22   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
  23   0.2382E+04   0.0000E+00   -0.1885E+04   0.2382E+04     0.00
  24   0.1641E+04   0.0000E+00   -0.1299E+04   0.1641E+04     0.00
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
UPPER CIRCLE SEARCH

TABLE NO. 23
*******************************************************************
* INFORMATION GENERATED DURING ITERATIVE SOLUTION FOR THE FACTOR *
* OF SAFETY AND SIDE FORCE INCLINATION BY SPENCER'S PROCEDURE    *
*******************************************************************

        Trial      Trial
       Factor   Side Force    Force      Moment                  Delta
Iter-    of    Inclination  Imbalance  Imbalance    Delta-F      Theta
ation  Safety   (degrees)    (lbs.)   (ft.-lbs.)               (degrees)

   1   1.50000     15.0000  0.1088E+04 -0.6728E+06
First-order corrections to F and THETA ......... -0.215E-01 0.345E+01
Second-order correction - Iteration   1 ........ -0.207E-01 0.345E+01
Second-order correction - Iteration   2 ........ -0.207E-01 0.345E+01

   2   1.47933     18.4484 -0.4069E+01 -0.3825E+05
First-order corrections to F and THETA .........  0.126E-01 0.470E+01
Second-order correction - Iteration   1 ........  0.131E-01 0.470E+01
Second-order correction - Iteration   2 ........  0.131E-01 0.470E+01

   3   1.49247     23.1509 -0.2382E+01  0.3188E+04
First-order corrections to F and THETA ......... -0.589E-03-0.222E+00
Second-order correction - Iteration   1 ........ -0.587E-03-0.222E+00

   4   1.49188     22.9292 -0.3662E-03  0.1571E+00
First-order corrections to F and THETA .........  0.134E-07 0.133E-05

FACTOR OF SAFETY - - - - - - - -      1.492
SIDE FORCE INCLINATION - - - - -      22.93
NUMBER OF ITERATIONS - - - - - -      4
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
UPPER CIRCLE SEARCH

TABLE NO. 24
*********************************************
* FINAL RESULTS FOR SHEAR SURFACE (CRITICAL *
* SURFACE IN CASE OF A SEARCH)              *
*********************************************

SPENCER'S PROCEDURE USED TO COMPUTE FACTOR OF SAFETY
Factor of Safety =  1.492     Side Force Inclination =  22.93 Degrees

       -------- VALUES AT CENTER OF BASE OF SLICE---------

                                    Total     Effective
Slice                               Normal     Normal      Shear
  No.    X-center   Y-center        Stress     Stress      Stress

   1        412.5      683.0          49.1       49.1        36.5
   2        415.8      683.1         293.5      293.5       151.2
   3        421.4      683.4         645.2      645.2       316.2
   4        427.0      684.0         919.2      919.2       444.8
   5        432.5      684.8        1125.5     1125.5       541.7
   6        438.0      686.0        1272.3     1272.3       610.5
   7        442.3      687.1        1355.0     1355.0       649.4
   8        446.7      688.5        1400.6     1400.6       670.8
   9        451.9      690.4        1421.9     1421.9       680.8
  10        457.1      692.5        1404.7     1404.7       672.7
  11        462.1      695.0        1353.5     1353.5       648.6
  12        467.0      697.7        1272.4     1272.4       610.6
  13        471.8      700.6        1165.5     1165.5       560.4
  14        474.3      702.3        1102.0     1102.0       530.6
  15        476.6      704.0        2223.7     2223.7      1057.1
  16        480.8      707.3        1848.2     1848.2       880.8
  17        485.1      711.0        1470.4     1470.4       703.5
  18        489.1      714.8        1107.6     1107.6       533.2
  19        492.9      718.9         882.7      882.7       427.7
  20        494.9      721.1         589.4      589.4       290.0
  21        495.2      721.5         562.8      562.8       277.5
  22        495.5      721.9         493.6      493.6       344.8
  23        497.3      724.2         516.5      516.5       255.8
  24        499.6      727.2         463.0      463.0       230.7

CHECK SUMS - (ALL SHOULD BE SMALL)
SUM OF FORCES IN VERTICAL DIRECTION    =         0.00   (= 0.397E-02)
     SHOULD NOT EXCEED    0.100E+03
SUM OF FORCES IN HORIZONTAL DIRECTION  =         0.00   (= 0.367E-02)
     SHOULD NOT EXCEED    0.100E+03
SUM OF MOMENTS ABOUT COORDINATE ORIGIN =         1.13   (= 0.113E+01)
```

```
      SHOULD NOT EXCEED    0.100E+03
 SHEAR STRENGTH/SHEAR FORCE CHECK-SUM   =          0.00  (= 0.267E-02)
      SHOULD NOT EXCEED    0.100E+03
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run:  10: 4:1990      Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
UPPER CIRCLE SEARCH

TABLE NO. 25
*********************************************
* FINAL RESULTS FOR SHEAR SURFACE (CRITICAL *
* SURFACE IN CASE OF A SEARCH)              *
*********************************************

SPENCER'S PROCEDURE USED TO COMPUTE FACTOR OF SAFETY
Factor of Safety =  1.492     Side Force Inclination =  22.93 Degrees

       --------------- VALUES AT RIGHT SIDE OF SLICE ----------------

                             Y-Coord. of   Fraction   Sigma      Sigma
Slice                  Side  Side Force      of        at         at
 No.     X-Right      Force   Location     Height     Top       Bottom

  1       413.0         41.       683.2    0.414       34.5      107.7
  2       418.6        914.       684.3    0.360       41.4      475.8
  3       424.2       2523.       685.3    0.306      -67.9      887.4
  4       429.7       4476.       686.6    0.288     -143.5     1203.0
  5       435.2       6468.       688.0    0.278     -207.8     1451.5
  6       440.7       8272.       689.6    0.268     -268.7     1646.7
  7       444.0       9216.       690.7    0.262     -306.9     1744.7
  8       449.3      10408.       692.6    0.251     -372.4     1874.4
  9       454.5      11117.       694.5    0.236     -447.3     1976.0
 10       459.6      11323.       696.7    0.216     -538.0     2060.8
 11       464.6      11047.       698.8    0.187     -654.7     2143.2
 12       469.4      10343.       701.0    0.144     -813.4     2244.4
 13       474.1       9294.       703.2    0.077    -1043.2     2398.8
 14       474.5       9198.       703.3    0.045     -750.6     1618.2
 15       478.7       6551.       705.2    BELOW     -513.8     1006.5
 16       483.0       3566.       706.0    BELOW     -452.1      765.9
 17       487.1        703.       691.1    BELOW     -362.4      437.9
 18       491.1      -1810.       724.6    0.587     -192.8      -60.2
 19       494.8      -2019.       726.4    0.601     -332.4      -81.1
 20       495.0      -2113.       726.3    0.573     -320.0     -125.5
 21       495.4      -2273.       726.1    0.528     -294.2     -210.4
 22       495.6      -2340.       726.1    0.508     -282.0     -256.7
 23       499.1      -1274.       728.1    0.463     -254.0     -400.8
 24       500.2          0.     -1393.9    BELOW       -2.1        2.1

CHECK SUMS - (ALL SHOULD BE SMALL)
SUM OF FORCES IN VERTICAL DIRECTION    =          0.00   (= 0.397E-02)
     SHOULD NOT EXCEED    0.100E+03
SUM OF FORCES IN HORIZONTAL DIRECTION  =          0.00   (= 0.367E-02)
     SHOULD NOT EXCEED    0.100E+03
SUM OF MOMENTS ABOUT COORDINATE ORIGIN =          1.13   (= 0.113E+01)
```

```
     SHOULD NOT EXCEED    0.100E+03
SHEAR STRENGTH/SHEAR FORCE CHECK-SUM   =        0.00  (= 0.267E-02)
     SHOULD NOT EXCEED    0.100E+03

***** CAUTION ***** FORCES BETWEEN SLICES ARE NEGATIVE AT POINTS
                    ALONG THE UPPER ONE-HALF OF THE SHEAR SURFACE -
                    A TENSION CRACK MAY BE NEEDED.

***** CAUTION ***** SOME OF THE FORCES BETWEEN SLICES ACT AT POINTS
                    ABOVE THE SURFACE OF THE SLOPE OR BELOW THE
                    SHEAR SURFACE - EITHER A TENSION CRACK MAY BE
                    NEEDED OR THE SOLUTION MAY NOT BE A VALID SOLUTION.
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
LOWER CIRCLE SEARCH

TABLE NO.  9
*********************************
* NEW ANALYSIS/COMPUTATION DATA *
*********************************

Circular Shear Surface(s)

Automatic Search Performed

Starting Center Coordinate for Search at -
                                             X =     310.000
                                             Y =     890.000

Required accuracy for critical center (= minimum
spacing between grid points) =       2.000

Critical shear surface not allowed to pass below Y =     590.000

For the initial mode of search
all circles are tangent to horizontal line at -
                                             Y =     615.000

Initial trial estimate for the factor of safety =   1.500

Depth of crack =       5.000

---------------------------------------------------------------------
THE FOLLOWING REPRESENT EITHER DEFAULT OR PREVIOUSLY DEFINED VALUES:

Initial trial estimate for side force inclination =  15.000 degrees
(Applicable to Spencer's procedure only)

Maximum number of iterations allowed for
calculating the factor of safety =   40

Allowed force imbalance for convergence =     100.000

Allowed moment imbalance for convergence =     100.000

Initial trial values for factor of safety (and side force inclination
for Spencer's procedure) will be kept constant during search

Short form of output will be used for search

Maximum subtended angle to be used for subdivision of the
circle into slices =   3.00 degrees
```

```
Search will be continued to locate a more critical shear
surface (if one exists) after the initial mode is complete

Depth of water in crack =        0.000

Unit weight of water in crack =    62.400

Seismic coefficient = 0.000

Procedure used to compute the factor of safety: SPENCER
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
LOWER CIRCLE SEARCH

TABLE NO. 14
*************************************************************
* SHORT-FORM TABLE FOR SEARCH WITH CIRCULAR SHEAR SURFACES *
*************************************************************
                   Center Coordinates of
                      Critical Circle
                                                    Factor   Side
                                                      of     Force
Mode                         X          Y      Radius  Safety  Inclin.

 2  Tangent Line       308.000    892.000    277.000   1.498    19.36
    at Y =     615.0

 3  Constant Radius    308.000    892.000    277.000   1.498    19.36
    of R =     277.0

TABLE NO. 15
***** FINAL CRITICAL CIRCLE INFORMATION *****
X Coordinate of Center - - - - - - -   308.000
Y Coordinate of Center - - - - - - -   892.000
Radius - - - - - - - - - - - - - - -   277.000
Factor of Safety - - - - - - - - - -     1.498
Side Force Inclination - - - - - - -     19.36

Number of circles tried  - - - - - -   70
No. of circles F calc. for - - - - -   64
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
LOWER CIRCLE SEARCH

TABLE NO. 20
*******************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)               *
*******************************************************************

Slice                     Slice    Matl.            Friction    Pore
  No.     X        Y      Weight   Type   Cohesion    Angle   Pressure

        241.9    623.0
   1    245.7    622.1     1766.3    3       20.00    35.00        0.0
        249.5    621.2
   2    256.7    619.9    12193.5    3       20.00    35.00      169.1
        263.8    618.6
   3    271.0    617.6    22959.8    3       20.00    35.00      484.7
        278.1    616.6
   4    284.1    616.1    26048.7    3       20.00    35.00      734.1
        290.0    615.6
   5    297.2    615.3    39325.3    3       20.00    35.00      907.0
        304.5    615.0
   6    306.2    615.0    10649.5    3       20.00    35.00      990.3
        308.0    615.0
   7    310.5    615.0    15840.6    3       20.00    35.00     1020.3
        313.0    615.0
   8    320.2    615.4    52605.6    3       20.00    35.00     1069.3
        327.5    615.7
   9    334.7    616.4    62867.7    3       20.00    35.00     1110.1
        341.9    617.1
  10    349.1    618.2    71435.4    3       20.00    35.00     1103.3
        356.3    619.2
  11    363.4    620.7    78239.0    3       20.00    35.00     1048.8
        370.5    622.1
  12    376.2    623.6    68008.3    3       20.00    35.00      959.9
        382.0    625.1
  13    383.5    625.5    18274.4    3       20.00    35.00      894.4
        385.0    625.9
  14    391.9    628.1    86502.0    3       20.00    35.00      997.4
        398.8    630.3
  15    399.4    630.5     7551.6    3       20.00    35.00     1125.1
        400.0    630.7
  16    403.6    632.0    44462.8    3       20.00    35.00     1184.2
        407.1    633.3
  17    408.6    633.9    17323.1    2       20.00    35.00     1252.6
        410.0    634.5
  18    416.7    637.3    80203.5    2       20.00    35.00     1340.2
        423.3    640.2
  19    429.8    643.3    79453.8    2       20.00    35.00     1451.4
```

	436.4	646.5					
20	440.2	648.6	46626.4	2	20.00	35.00	1505.3
	444.0	650.7					
21	450.2	654.4	74922.0	2	20.00	35.00	1497.2
	456.4	658.1					

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
LOWER CIRCLE SEARCH

TABLE NO. 20
*****************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)              *
*****************************************************************

Slice                         Slice   Matl.             Friction     Pore
 No.      X        Y          Weight  Type   Cohesion    Angle     Pressure

        456.4    658.1
  22    462.5    662.2      70205.0     2       20.00     35.00      1430.1
        468.5    666.2
  23    471.5    668.4      33893.5     2       20.00     35.00      1348.4
        474.5    670.6
  24    480.2    675.1      77893.7     2       20.00     35.00      1226.2
        485.9    679.6
  25    490.4    683.6      52974.1     2       20.00     35.00      1044.9
        495.0    687.6
  26    500.2    692.7      48477.7     2       20.00     35.00       815.2
        505.4    697.7
  27    505.7    698.0       2221.0     2       20.00     35.00       671.0
        506.0    698.3
  28    507.0    699.3       7574.2     2       20.00     35.00       632.4
        508.0    700.4
  29    510.0    702.4      13207.5     2       20.00     35.00       815.6
        511.9    704.5
  30    512.0    704.6        311.2     2       20.00     35.00      1025.8
        512.0    704.6
  31    513.0    705.7       3826.8     2       20.00     35.00       954.0
        514.0    706.8
  32    517.1    710.4       7352.9     1      200.00     32.50       659.6
        520.3    714.1
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
LOWER CIRCLE SEARCH

TABLE NO. 21
*******************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)              *
*******************************************************************

                                       FORCES DUE TO SURFACE PRESSURES
                            Y for
Slice            Seismic   Seismic    Normal   Shear
  No.      X      Force     Force     Force    Force        X        Y

   1    245.7      0.       623.0      0.       0.        0.0      0.0
   2    256.7      0.       623.3      0.       0.        0.0      0.0
   3    271.0      0.       624.0      0.       0.        0.0      0.0
   4    284.1      0.       624.9      0.       0.        0.0      0.0
   5    297.2      0.       626.2      0.       0.        0.0      0.0
   6    306.2      0.       627.2      0.       0.        0.0      0.0
   7    310.5      0.       627.7      0.       0.        0.0      0.0
   8    320.2      0.       629.9      0.       0.        0.0      0.0
   9    334.7      0.       633.8      0.       0.        0.0      0.0
  10    349.1      0.       638.1      0.       0.        0.0      0.0
  11    363.4      0.       642.7      0.       0.        0.0      0.0
  12    376.2      0.       647.2      0.       0.        0.0      0.0
  13    383.5      0.       649.9      0.       0.        0.0      0.0
  14    391.9      0.       653.2      0.       0.        0.0      0.0
  15    399.4      0.       656.1      0.       0.        0.0      0.0
  16    403.6      0.       657.0      0.       0.        0.0      0.0
  17    408.6      0.       658.0      0.       0.        0.0      0.0
  18    416.7      0.       661.4      0.       0.        0.0      0.0
  19    429.8      0.       667.8      0.       0.        0.0      0.0
  20    440.2      0.       673.0      0.       0.        0.0      0.0
  21    450.2      0.       678.5      0.       0.        0.0      0.0
  22    462.5      0.       685.5      0.       0.        0.0      0.0
  23    471.5      0.       690.9      0.       0.        0.0      0.0
  24    480.2      0.       702.6      0.       0.        0.0      0.0
  25    490.4      0.       706.8      0.       0.        0.0      0.0
  26    500.2      0.       711.3      0.       0.        0.0      0.0
  27    505.7      0.       714.0      0.       0.        0.0      0.0
  28    507.0      0.       714.6      0.       0.        0.0      0.0
  29    510.0      0.       716.2      0.       0.        0.0      0.0
  30    512.0      0.       717.3      0.       0.        0.0      0.0
  31    513.0      0.       713.6      0.       0.        0.0      0.0
  32    517.1      0.       715.3      0.       0.        0.0      0.0
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
LOWER CIRCLE SEARCH

TABLE NO. 22
*******************************************************************
* INFORMATION FOR INDIVIDUAL SLICES (INFORMATION IS FOR CRITICAL *
* SHEAR SURFACE IN THE CASE OF AN AUTOMATIC SEARCH)               *
*******************************************************************

        INTERNAL FORCES DUE TO SOIL REINFORCEMENT

                                     Moment about
Slice   Horizontal    Vertical       Center of     Resultant     Angle
  No.     Force         Force        Slice Base      Force      (degs.)

    1   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
    2   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
    3   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
    4   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
    5   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
    6   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
    7   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
    8   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
    9   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   10   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   11   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   12   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   13   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   14   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   15   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   16   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   17   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   18   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   19   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   20   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   21   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   22   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   23   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   24   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   25   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   26   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   27   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   28   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   29   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   30   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   31   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
   32   0.0000E+00   0.0000E+00    0.0000E+00   0.0000E+00     0.00
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
LOWER CIRCLE SEARCH

TABLE NO. 23
*****************************************************************
* INFORMATION GENERATED DURING ITERATIVE SOLUTION FOR THE FACTOR *
* OF SAFETY AND SIDE FORCE INCLINATION BY SPENCER'S PROCEDURE    *
*****************************************************************

        Trial     Trial
       Factor   Side Force    Force       Moment                 Delta
Iter-    of    Inclination  Imbalance   Imbalance    Delta-F     Theta
ation  Safety   (degrees)     (lbs.)    (ft.-lbs.)             (degrees)

   1    1.50000    15.0000  0.9508E+04 -0.6893E+07
First-order corrections to F and THETA ......... -0.811E-02 0.376E+01
Second-order correction - Iteration   1 ........ -0.645E-02 0.376E+01
Second-order correction - Iteration   2 ........ -0.645E-02 0.376E+01

   2    1.49355    18.7572 -0.6725E+02 -0.2546E+06
First-order corrections to F and THETA .........  0.468E-02 0.611E+00
Second-order correction - Iteration   1 ........  0.471E-02 0.611E+00
Second-order correction - Iteration   2 ........  0.471E-02 0.611E+00

   3    1.49826    19.3680 -0.1216E+00  0.2065E+04
First-order corrections to F and THETA ......... -0.309E-04-0.422E-02
Second-order correction - Iteration   1 ........ -0.309E-04-0.422E-02

   4    1.49823    19.3638 -0.1465E-01  0.1990E+02
First-order corrections to F and THETA ......... -0.154E-06-0.273E-04

FACTOR OF SAFETY - - - - - - - -      1.498
SIDE FORCE INCLINATION - - - - -      19.36
NUMBER OF ITERATIONS - - - - - -      4
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
LOWER CIRCLE SEARCH

TABLE NO. 24
*************************************
* FINAL RESULTS FOR SHEAR SURFACE (CRITICAL *
* SURFACE IN CASE OF A SEARCH)              *
*************************************

SPENCER'S PROCEDURE USED TO COMPUTE FACTOR OF SAFETY
Factor of Safety =  1.498     Side Force Inclination =  19.36 Degrees

      -------- VALUES AT CENTER OF BASE OF SLICE---------

                                 Total    Effective
Slice                            Normal    Normal      Shear
  No.    X-center  Y-center      Stress    Stress      Stress

   1       245.7     622.1       369.4     369.4       186.0
   2       256.7     619.9      1203.9    1034.8       497.0
   3       271.0     617.6      2059.9    1575.1       749.5
   4       284.1     616.1      2684.9    1950.8       925.1
   5       297.2     615.3      3176.3    2269.3      1073.9
   6       306.2     615.0      3460.5    2470.2      1167.8
   7       310.5     615.0      3569.3    2549.0      1204.6
   8       320.2     615.4      3992.7    2923.4      1379.6
   9       334.7     616.4      4618.9    3508.8      1653.2
  10       349.1     618.2      5090.5    3987.2      1876.8
  11       363.4     620.7      5420.5    4371.7      2056.5
  12       376.2     623.6      5611.1    4651.2      2187.1
  13       383.5     625.5      5679.4    4784.9      2249.6
  14       391.9     628.1      5696.5    4699.0      2209.5
  15       399.4     630.5      5703.7    4578.6      2153.2
  16       403.6     632.0      5502.4    4318.2      2031.5
  17       408.6     633.9      5225.3    3972.7      1870.0
  18       416.7     637.3      5112.6    3772.4      1776.4
  19       429.8     643.3      5006.8    3555.4      1675.0
  20       440.2     648.6      4870.3    3365.0      1586.0
  21       450.2     654.4      4669.2    3172.0      1495.8
  22       462.5     662.2      4359.7    2929.7      1382.5
  23       471.5     668.4      4087.7    2739.2      1293.6
  24       480.2     675.1      4782.5    3556.2      1675.4
  25       490.4     683.6      3892.2    2847.3      1344.1
  26       500.2     692.7      2995.8    2180.6      1032.5
  27       505.7     698.0      2489.1    1818.2       863.1
  28       507.0     699.3      2366.7    1734.4       823.9
  29       510.0     702.4      2136.5    1320.8       630.7
  30       512.0     704.6      2001.1     975.3       469.2
  31       513.0     705.7      1292.9     338.9       171.7
  32       517.1     710.4       737.3      77.7       166.5
```

```
CHECK SUMS - (ALL SHOULD BE SMALL)
SUM OF FORCES IN VERTICAL DIRECTION     =          0.05   (= 0.545E-01)
     SHOULD NOT EXCEED    0.100E+03
SUM OF FORCES IN HORIZONTAL DIRECTION   =          0.07   (= 0.719E-01)
     SHOULD NOT EXCEED    0.100E+03
SUM OF MOMENTS ABOUT COORDINATE ORIGIN =        -17.28   (=-0.173E+02)
     SHOULD NOT EXCEED    0.100E+03
SHEAR STRENGTH/SHEAR FORCE CHECK-SUM    =          0.02   (= 0.215E-01)
     SHOULD NOT EXCEED    0.100E+03
```

```
UTEXAS2 - VER. 1.211 -  4/10/87 - SNNONE  - (C) 1985 S. G. WRIGHT
Date of this run: 10: 4:1990     Time of this run:  7:56:42
MIDDLE CREEK DAM
DOWNSTREAM SLOPE - DRAIN FAILED
LOWER CIRCLE SEARCH

TABLE NO. 25
**********************************************
* FINAL RESULTS FOR SHEAR SURFACE (CRITICAL *
* SURFACE IN CASE OF A SEARCH)              *
**********************************************

SPENCER'S PROCEDURE USED TO COMPUTE FACTOR OF SAFETY
Factor of Safety =  1.498     Side Force Inclination =  19.36 Degrees

       --------------- VALUES AT RIGHT SIDE OF SLICE ----------------

                             Y-Coord. of   Fraction   Sigma      Sigma
Slice                  Side  Side Force      of        at         at
  No.    X-Right      Force   Location     Height     Top       Bottom

   1      249.5       2197.       623.5     0.602      902.7      218.5
   2      263.8      13136.       623.4     0.487     1142.2     1338.2
   3      278.1      28789.       623.9     0.470     1425.6     2063.5
   4      290.0      43336.       624.8     0.468     1690.5     2482.4
   5      304.5      61727.       626.3     0.472     2040.7     2848.0
   6      308.0      66152.       626.7     0.474     2125.1     2921.2
   7      313.0      72366.       627.4     0.462     1966.8     3138.5
   8      327.5      90838.       629.5     0.430     1554.2     3778.5
   9      341.9     109285.       631.9     0.396     1031.3     4460.9
  10      356.3     126202.       634.8     0.369      609.7     5039.6
  11      370.5     140515.       638.1     0.348      245.8     5524.4
  12      382.0     149808.       641.1     0.332      -31.1     5865.3
  13      385.0     151845.       642.0     0.327     -102.5     5948.1
  14      398.8     157677.       646.2     0.311     -386.6     6205.1
  15      400.0     157876.       646.6     0.315     -322.7     6228.9
  16      407.1     157943.       649.1     0.324     -169.0     6293.6
  17      410.0     157437.       650.2     0.319     -257.8     6290.4
  18      423.3     151711.       655.4     0.314     -340.7     6222.4
  19      436.4     140964.       661.1     0.298     -580.1     6013.7
  20      444.0     132390.       664.7     0.288     -704.1     5832.4
  21      456.4     115255.       670.9     0.268     -888.7     5454.6
  22      468.5      95511.       677.4     0.244    -1051.5     4995.2
  23      474.5      84690.       680.8     0.202    -1252.4     4421.6
  24      485.9      59149.       688.1     0.168    -1101.3     3317.6
  25      495.0      39149.       694.4     0.159     -911.1     2655.2
  26      505.4      18606.       702.0     0.132     -657.2     1744.6
  27      506.0      17610.       702.4     0.130     -640.1     1687.9
  28      508.0      14175.       703.9     0.121     -575.2     1477.3
  29      511.9       7373.       707.3     0.110     -364.8      910.6
  30      512.0       7192.       707.4     0.133     -385.3     1025.2
  31      514.0       4552.       709.3     0.174     -283.3      876.3
  32      520.3          0.      2508.9     ABOVE        4.0       -4.0
```

```
CHECK SUMS - (ALL SHOULD BE SMALL)
SUM OF FORCES IN VERTICAL DIRECTION     =         0.05  (= 0.545E-01)
     SHOULD NOT EXCEED    0.100E+03
SUM OF FORCES IN HORIZONTAL DIRECTION   =         0.07  (= 0.719E-01)
     SHOULD NOT EXCEED    0.100E+03
SUM OF MOMENTS ABOUT COORDINATE ORIGIN  =       -17.28  (=-0.173E+02)
     SHOULD NOT EXCEED    0.100E+03
SHEAR STRENGTH/SHEAR FORCE CHECK-SUM    =         0.02  (= 0.215E-01)
     SHOULD NOT EXCEED    0.100E+03


END-OF-FILE ENCOUNTERED WHILE READING COMMAND
WORDS - END OF PROBLEM(S) ASSUMED
```

UPSTREAM FACE

FINAL STABILITY ANALYSIS

```
                     SLICE DATA FOR THE CRITICAL ARC AFTER DRAWDOWN
                     **********************************************
       FACTOR OF SAFETY AFTER DRAWDOWN=  1.169
       LOCATION OF CENTER; X=  560.00   Y=  840.00
       ARC RADIUS= 193.00

                                   TABULATION OF SLICE DATA
                                   ************************
   SLICE    SLICE    X-COORD.    TOTAL     WATER    DIR. OF    C-FORCE    DIR. OF
    NO.     WIDTH   OF SLICE    WEIGHT     FORCE   W. FORCE     DEVEL.    C-FORCE
  *******  *******  ********  ********  *******  ********  ********  *********
     1       4.58    503.71      1.85      0.00       0.0        0.0     -54.08
     2       1.27    506.64      1.14      0.00       0.0        0.0     -52.62
     3       4.33    509.44      5.75      0.00       0.0       1.18     -51.27
     4       0.30    511.75      0.50     -0.41       0.0       0.08     -50.19
     5       0.10    511.95      0.08      1.03       0.0       0.03     -50.09
     6      14.00    519.00     18.88      4.86       0.0       3.51     -46.93
     7      26.00    539.00     70.99     32.20       0.0       5.71     -38.82
     8      26.00    565.00     98.96     45.35       0.0       5.11     -29.49
     9      26.00    591.00    109.39     51.22       0.0       4.76     -20.95
    10      26.00    617.00    105.72     51.53       0.0       4.55     -12.87
    11       4.00    632.00     15.06      7.59       0.0       0.69      -8.34
    12      10.00    639.00     35.74     19.64       0.0       1.72      -6.25
    13      16.00    652.00     51.67     23.24       0.0       2.74      -2.38
    14      19.67    669.84     52.36     28.76       0.0       3.37       2.92
    15      19.67    689.51     35.30     21.01       0.0       3.40       8.79
    16      19.67    709.18     13.11      9.19       0.0       3.48      14.76


   SLICE     PHI     NORMAL     NORMAL          ALPHA              SIDE FORCES
    NO.     DEVEL.   STRESS     FORCE      TOP      BOTTOM        E1          E2
  *******  *******  ********  ********  *******  ********  *********  *********
     1      29.98      0.23      1.76      0.0       0.0        0.0        0.0
     2      29.98      0.51      1.07      0.0       0.0        0.0        0.0
     3      22.64      0.73      5.08      0.0       0.0        0.0        0.0
     4      22.64      1.56      0.73      0.0     -43.57       0.0        0.0
     5      22.64     -6.53     -1.02    -43.57    -55.17       0.0        0.47
     6      22.64      0.54     11.06    -55.17    -21.18       0.47       6.81
     7      22.64      0.97     32.40    -21.18    -19.16       6.81      33.74
     8      22.64      1.52     45.29    -19.16    -19.16      33.74      58.86
     9      22.64      1.34     51.35    -19.16    -19.16      58.86      71.80
    10      22.64      1.94     51.82    -19.16    -19.16      71.80      69.17
    11      22.64      1.89      7.64    -19.16    -19.16      69.17      67.44
    12      22.64      2.00     20.08    -19.16    -16.60      67.44      60.51
    13      22.64      1.79     28.74    -16.60    -14.04      60.51      47.05
    14      22.64      1.48     29.07    -14.04    -14.04      47.05      28.06
    15      22.64      1.07     21.32    -14.04    -14.04      28.06       8.37
    16      22.64      0.46      9.40    -14.04    -14.04       8.87      -3.39


  *** NOTES ***
  1) ALL ANGLES MEASURED FROM THE (+) X AXIS.
  2) ALL FORCES ARE MEASURED IN KIPS.
  3) HORIZONTAL EARTHQUAKE FORCE MAY BE CALCULATED BY MULTIPLYING THE
  TOTAL SLICE WT. BY THE EARTHQUAKE COEFFICIENT
```

```
PROGRAM SLOPE - SLOPE STABILITY                                   DATE:  6/16/88


MIDDLE CREEK DAM
JUNE 16,1988
SUDDEN DRAWDOWN WITH THE REINFORCED EARTH ALTERNATIVE
COE PROGRAM WITH SEISMIC COEF. OF 0.0
FAILURE PLANE ELEVATION 647


****************************************************************************

                              INPUT DATA

    MINIMUM ELEVATION OF CIRCLE= 647.0  X-START= 560.0  Y-START= 840.0
                      SEARCH INCREMENT=    0.0  F.S. MIN.= 0.0

    NUMBER OF LINES= 25  MIN. NO. OF SLICES=  8  SEISMIC COEFF.= 0.0

EMBANKMENT AND FOUNDATION PROFILE:
********************************

      XTOEL    YTOEL    XTOPL    YTOPL    XTOER    YTOER    XTOPR    YTOPR
      *****    *****    *****    *****    *****    *****    *****    *****
        0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0

      X1(I)        Y1(I)        X2(I)        Y2(I)        TYPE
( 1) -5000.0       605.0        206.0        606.0         5
( 2)   206.0       606.0        230.0        620.0         5
( 3)   230.0       620.0        313.0        641.0         3
( 4)   313.0       641.0        400.0        682.0         3
( 5)   400.0       682.0        410.0        682.0         3
( 6)   410.0       682.0        474.5        715.0         3
( 7)   474.5       715.0        474.6        730.0         3
( 8)   474.6       730.0        511.9        730.0         3
( 9)   511.6       730.0        512.0        722.0         3
(10)   512.0       722.0        526.0        716.0         1
(11)   495.0       722.0        512.0        722.0         1
(12)   526.0       716.0        644.0        675.0         1
(13)   644.0       675.0        796.0        637.0         1
(14)   796.0       637.0        943.0        632.0         1
(15)   943.0       632.0       5000.0        632.0         4
(16)   230.0       620.0        382.0        608.0         5
(17)   382.0       608.0        495.0        722.0         2
(18)   382.0       608.0        506.0        611.0         5
(19)   495.0       722.0        630.0        614.0         2
(20)   506.0       611.0        630.0        614.0         4
(21)   506.0       611.0        634.0        590.0         5
(22)   630.0       614.0        916.0        597.0         4
(23)   634.0       590.0       5000.0        590.0         5
(24)   916.0       597.0        943.0        632.0         4
(25) -5000.0       560.0       5000.0        560.0         6

SOIL CONSTANTS;
***************
NUMBER OF SOIL TYPES= 6
     TYPE NO.   WT.MOIST   WT. SAT.   C(1)    PHI(1)     C(2)    PHI(2)
( 1)    1        120.0     125.0     200.0     26.0      0.0      0.0
( 2)    2        125.0     130.0       0.0     30.0      0.0      0.0
( 3)    3        125.0     130.0       0.0     34.0      0.0      0.0
( 4)    4        100.0     105.0       0.0     28.0      0.0      0.0
( 5)    5        130.0     130.0       0.0     34.0      0.0      0.0
( 6)    6        135.0     135.0    1000.0     30.0      0.0      0.0
```

```
PIEZOMETRIC SURFACE DATA;
*************************
NUMBER OF POINTS FOR PIEZOMETRIC SURFACE=  9

            XPIEZ(I)     YPIEZ(I)
( 1)     5000.0        721.0
( 2)      511.9        721.0
( 3)      511.8        706.0
( 4)      512.0        700.0
( 5)      420.0        670.0
( 6)      369.0        632.0
( 7)      326.0        620.0
( 8)      220.0        611.0
( 9)    -5000.0        611.0

DRAWDOWN SURFACE DATA;
*********************
NUMBER OF POINTS FOR DRAWDOWN SURFACE=  4
            XSUD(I)      YSUD(I)
( 1)     5000.0        637.0
( 2)      796.0        637.0
( 3)      220.0        611.0
( 4)    -5000.0        606.0
****************************************************************************************
```

```
MIDDLE CREEK DAM
JUNE 16,1988
SUDDEN DRAWDOWN WITH THE REINFORCED EARTH ALTERNATIVE
COE PROGRAM WITH SEISMIC COEF. OF 0.0
FAILURE PLANE ELEVATION 547


          CHECK DATA FOR THE BEFORE OR NON-DRAWDOWN CRITICAL ARC
          ***********************************************************
   FACTOR OF SAFETY= 2.234
   LOCATION OF CENTER; X=   560.00   Y=   840.00
   ARC RADIUS= 193.00


                              TABULATION OF SLICE DATA
                              ************************
  SLICE     SLICE    X-COORD.    TOTAL     WATER    DIR. OF    C-FORCE    DIR. OF
   NO.      WIDTH    OF SLICE    WEIGHT    FORCE    W. FORCE    DEVEL.    C-FORCE
 *******  *******  ********  ********  *******  ********  *********  *********
    1       4.58    503.71      1.85      0.0       0.0        0.0      -54.08
    2       1.27    506.64      1.14      0.0       0.0        0.0      -52.62
    3       4.33    509.44      5.75      0.0       0.0        0.62     -51.27
    4       0.30    511.75      0.50      0.0       0.0        0.04     -50.19
    5       0.10    511.95      0.08      0.03     90.00       0.01     -50.09
    6      14.00    519.00     18.88      9.42     90.00       1.84     -46.93
    7      26.00    539.00     70.99     35.44     90.00       2.99     -38.82
    8      26.00    565.00     98.96     49.40     90.00       2.67     -29.49
    9      26.00    591.00    109.39     54.61     90.00       2.49     -20.95
   10      26.00    617.00    105.72     52.78     90.00       2.39     -12.87
   11       4.00    632.00     15.06      7.52     90.00       0.36      -8.34
   12      10.00    639.00     35.74     17.84     90.00       0.90      -6.25
   13      16.00    652.00     51.67     25.79     90.00       1.43      -2.38
   14      19.67    669.34     52.36     26.14     90.00       1.76       2.92
   15      19.67    689.51     35.30     17.62     90.00       1.73       8.79
   16      19.67    709.18     13.11      6.55     90.00       1.82      14.76


  SLICE      PHI     NORMAL     NORMAL          ALPHA              SIDE FORCES
   NO.     DEVEL.    STRESS     FORCE      TOP      BOTTOM        E1           E2
 *******  *******  ********  ********  *******  ********  *********  *********
    1      16.80      0.29      2.23      0.0       0.0        0.0        1.41
    2      16.80      0.64      1.35      0.0       0.0        1.41       2.23
    3      12.32      0.96      6.62      0.0       0.0        2.23       6.11
    4      12.32     -8.07     -3.73      0.0     -43.57       6.11       5.11
    5      12.32     -6.53     -1.02    -43.57    -55.17       5.11       5.35
    6      12.32      0.54     11.06    -55.17    -21.18       5.35       8.93
    7      12.32      0.97     32.40    -21.18    -19.16       8.83      21.92
    8      12.32      1.52     45.29    -19.16    -19.16      21.92      33.95
    9      12.32      1.84     51.35    -19.16    -19.16      33.95      39.83
   10      12.32      1.94     51.82    -19.16    -19.16      39.83      37.92
   11      12.32      1.89      7.64    -19.16    -19.16      37.92      36.97
   12      12.32      2.00     20.03    -19.16    -16.60      36.97      33.23
   13      12.32      1.79     28.74    -16.60    -14.04      33.23      26.12
   14      12.32      1.48     29.07    -14.04    -14.04      26.12      16.24
   15      12.32      1.07     21.32    -14.04    -14.04      16.24       6.33
   16      12.32      0.46      9.40    -14.04    -14.04       6.33      -0.00


 *** NOTES ***
 1) ALL ANGLES MEASURED FROM THE (+) X AXIS.
 2) ALL FORCES ARE MEASURED IN KIPS.
 3) HORIZONTAL EARTHQUAKE FORCE MAY BE CALCULATED BY MULTIPLYING THE
 TOTAL SLICE WT. BY THE EARTHQUAKE COEFFICIENT
```

APPENDIX E

EARTH REINFORCED SECTION DATA

APPENDIX E-1
VALUE ENGINEERING ANALYSES

MIDDLE CREEK DAM
VALUE ENGINEERING ANALYSES

HKM, in response to USBR comments, has performed a value engineering analysis to re-evaluate the use of RCC on the Middle Creek Dam embankment. RCC was considered during the initial design phase but was ruled out for numerous reasons including the non-rock foundation of the existing embankment combined with high seismic activity in the region. However, recent worldwide experience in RCC construction has resulted in acceptance of RCC surfacing placed on embankments with non-rock foundations. This experience prompted the USBR comments.

METHODOLOGY

Six characteristics were identified that could be used to estimate the relative "value" of the proposed mechanically stabilized earth alternative versus an RCC alternative. Characteristics having the same "value" for both alternatives were excluded from the analysis.

The characteristics are as follows:

- Risk
- Cost
- Constructability
- Operation and Maintenance
- Aesthetics and Environment
- Recreation Enhancement

A discussion of each of these characteristics follows.

Risk

Both alternative plans are considered to be feasible from an engineering standpoint. Each carries some risk but the level of risk appears different. The primary difference includes three engineering criteria:

1. Local seismic activity is eminent and must be accommodated in the design.
2. Internal seepage and erosion must be controlled.
3. Conventional engineering technology is preferred where it is adequate.

Because the project is located in a high seismic activity zone, the structure must anticipate movements created by such activity. The mechanically stabilized earth structure is articulated and capable of differential movements throughout. Only the footing under the walk would be constructed in monolithic concrete pours. The earthen auxiliary spillway is not subject to significant damage during seismic activity.

The RCC section is a rigid material placed on an earth embankment. Cracking may result from settlement in the embankment and/or foundation. Seismic activity has the potential of cracking the RCC section. Additionally the dam has a non-rock foundation. The RCC section would not be supported on rock. While this is still acceptable this condition allows greater potential movement during seismic activity.

Seepage control under the RCC section on the downstream face is critical in view of the fact that the RCC section may have cracks in it as a result of seismic activity or differential movements. If storm water passing over the crest was able to penetrate the RCC facing, significant internal erosional damage could result. Additional seepage items pertain more to construction and are discussed later.

Both the mechanically stabilized earth sections and the RCC section for dam rehabilitation are relatively new. However, the excavation of the auxiliary spillway and the mechanically stabilized earth technology is well understood. There are more risks associated with the RCC plan at this site.

Cost

The cost of the RCC plan ($1,153,000) is approximately $347,000 more than the mechanically stabilized earth structure ($1,196,000) (Table 1).

Constructability

There are three primary factors which are used for value analysis for the alternatives for this project. These include:

1. Time requirements to complete the work.
2. Materials source and processing requirements.
3. Complexity of work and potential for error.

Both alternatives, excluding construction of the principal spillway, could be built in a single construction season. Approximately 95,000 CY of unclassified excavation is required for the mechanically stabilized earth structure while 105,000 CY is required for the RCC alternative. Material specifications require extensive washing to produce the RCC while only minor processing is anticipated for the mechanically stabilized earth structure.

TABLE 1

Cost Comparison[1]

	Unit	Mechanically Stabilized Earth		RCC		
	Price	Quantity	Total	Quantity	Total	Diff. +/(-)
Unclassified Excavation	$2.00	95,000 C.Y.	$190,000	105,000 C.Y.	$210,000	$20,000
Embankment - Zone I	$4.50	10,030 C.Y.	$45,135	9,027 C.Y.	$40,622	($4,513)
Embankment - Zone II	$2.50	38,200 C.Y.	$95,500	34,380 C.Y.	$85,950	($9,550)
Drain Gravel - Grade B	$10.00	-----	-----	3,000 C.Y.	$30,000	$30,000
Auxiliary Spillway Concrete Crest	$150.00	570 Ft.	$85,500	-----	-----	($85,500)
4-Inch Perforated PE Drain Tubing	$2.50	1,540 Ft.	$3,850	2,540 Ft.	$6,350	$2,500
RCC	$30.00	-----	-----	39,000 C.Y.	$1,170,000	$1,170,000
Mechanically Stabilized Earth	$776,000.00	Lump Sum	$ 776,000	-----	-----	($776,000)
			$1,195,985		$1,542,922	$346,937
		Use	$1,196,000		$1,543,000	$347,000

[1] Only costs that differ between alternatives are included. Cost data from 13-Dec-88.

The mechanically stabilized earth structure can be built using conventional earth moving and lifting equipment while aggregate processing and concrete mix plant equipment is required for the RCC.

Operation and Maintenance

Some maintenance will be required for both alternatives such as monitoring, gate operation and snow removal. Maintenance for the RCC section would include repair of cracking on the downstream face due to settlement, seismic activity, and/or freeze/thaw action. It is anticipated that this would consist of grout fillers. Crack repairs may be extensive following a seismic event.

The mechanically stabilized earth section would require maintenance of the concrete panels to reduce leak potential. Erosion and vegetative growth on the downstream face would need to be checked regularly.

Road surface grading and repair would be more often on the mechanically stabilized earth section as the road will be a flexible system with a soil base. The road will be paved in the future. The road on the RCC would likely consist of a concrete pavement with low maintenance requirements (possible cracking).

While the overall operation and maintenance program for the mechanically stabilized earth section is anticipated to be frequent, more critical and costly maintenance is anticipated for the RCC plan.

Aesthetics and Environment

During the initial phases of the final rehabilitation design the U.S. Forest Service and others expressed a desire to develop an aesthetically pleasing rehabilitation design. It was hoped that the structure would blend into the natural environment.

Both the mechanically stabilized earth wall plan and the RCC plan would have large exposed concrete surfaces. The amount of exposed natural gray color concrete will be larger for the RCC plan. However, the RCC plan would have natural appearing slopes and rough surface finishes while the mechanically stabilized earth structure would have vertical walls with distinct lines and a smooth gray finished surface. The RCC will be most obvious from the downstream side while the mechanically stabilized earth structure will be obvious from both sides.

To provide a basis for valuation, all disturbed areas differing between alternatives are tabulated below.

Mechanically stabilized earth structure:

1. Auxiliary spillway area
2. Borrow area upstream of auxiliary spillway

RCC structure:

1. Dike area across Blackmore campground
2. Borrow area for processing RCC. This borrow area would be the same as for the earth reinforced structure plan but less of a volume would be required.
3. The gravel processing for preparation of aggregate for RCC would require washing sediment. Control would be required in the processing.

Recreation Enhancement

The mechanically stabilized earth structure alternative allows for expansion of the Blackmore recreation facility. A day-use area would be developed. A boat ramp and beaching area will be constructed.

The RCC plan would not require a total rebuilding of the Blackmore campground, however, some rehabilitation would be required as a 10 foot high dike would need to be constructed through the area. While new camp sites would be needed, the day-use area could not be developed to the same extent. The recreation plan for the RCC plan would appear less costly unless extensive extras are requested by the USFS. It is assumed that the Chisholm and Hood Campground construction and rehabilitation would not change for either plan.

It is difficult to determine the value of recreation enhancement. The USFS policy has been that the less disturbance of the forest and camp area the greater the value to the environment. From the project owner's viewpoint, it appears that the recreation facility expansion which is a more natural result of the mechanically stabilized earth structure plan is of more recreational value.

COMPUTATIONS

The six characteristics were assigned two values. The first indicates the characteristic's relative importance and the second denotes relative "value", or the degree to which either alternative possesses each characteristic. A weighted value is then determined by multiplying the numbers assigned for relative importance and relative value. Total weighted value is determined by summing the weighted values for each alternative. Table 2 summarizes these computations.

TABLE 2

VALUE COMPARISON

Characteristics	Relative Importance	Mechanically Stabilized Earth Alternative		RCC Alternative	
		Relative Value	Weighted Value	Relative Value	Weighted Value
Risk	10	8	80	5	50
Cost	9	10	90	8	72
Constructability	7	6	42	5	35
Operation & Maintenance	5	7	35	4	20
Aesthetics & Environment	4	4	16	5	20
Recreation Enhancement	2	5	10	4	8
Total Weighted Value			273		205
Cost (assume RCC alter. uses same baffled drop structures for principal spillway)			\$1,196,000		\$1,543,000
Ratio of Value to Cost			$\frac{273}{\$1,196,000} = .000228$		$\frac{205}{\$1,543,000} = .000133$
Cost for mechanically stabilized earth alternative assuming ratios equal			$\frac{273}{.000133} = \$2,053,000$		

Costs associated with items that differ between the two alternatives are as follows:

RCC alternative	$1,543,000
Mechanically stabilized earth	$1,196,000

Total weighted value was divided by cost to determine the ratio of value to cost (Table 2). Assuming the ratio for RCC also applied to mechanically stabilized earth, the cost of the mechanically stabilized earth would have to increase from $1,196,000 to $2,053,000 to make the alternatives equal.

SUMMARY

The "value" of an RCC alternative has been compared with the proposed use of mechanically stabilized earth, as requested by the USBR. The mechanically stabilized earth alternative is preferrable to RCC in weighted total value (273 vs. 205), lower cost ($1,196,000 vs. $1,543,000), and value/cost (.000228 vs. .000133). Therefore, mechanically stabilized earth will be used for this project.

APPENDIX E-2
REINFORCED EARTH DESIGN DATA

reinforced earth

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The Reinforced Earth Company
Corporate Headquarters • Arlington, Virginia
Western Division
2710 Gateway Oaks Drive, Suite 215 - South
Sacramento, CA 95833
(916) 649-9991

LOCATION: PROJECT NO: 3085 SHEET 1 OF 28

SUBJECT: COVER SHEET DESG: dpm CHKD: RLA DATE:

MONTANA

DEPARTMENT NATURAL RESOURCES & CONSERVATION

MIDDLE CREEK DAM CREST RAISING.

BOZEMAN, MONTANA

REINFORCED EARTH WALL DESIGN CALCULATIONS

RECO PROJECT NO. 3085

OCTOBER 2, 1989

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LOCATION: MIDDLE CREEK DAM
BOZEMAN MONTANA

PROJECT NO: 3085

SHEET 2 OF

SUBJECT: INDEX TO CALCULATIONS DESG: dpm CHKD: RA DATE:

INDEX

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA
PROJECT NO: 3085
SHEET 3 OF
SUBJECT: DISCUSSION.
DESG: dpm
CHKD: RLA
DATE:

DISCUSSION.

THIS STRUCTURE WILL BE CONSTRUCTED USING SELECT GRANULAR MATERIAL, MEETING THE REQUIREMENTS FOR REINFORCED EARTH BACKFILL DEFINED IN THE SPECIFICATIONS. THE WALLS SHALL BE CONSTRUCTED IN SUCH A MANNER AS TO PROVIDE A WATERTIGHT SEAL ON THE UPSTREAM PORTION OF THE CREST STRUCTURE, THUS PREVENTING THE POSSIBILITY OF WATER ENTERING THE REINFORCED VOLUME. BECAUSE NO WATER ENTERS THE VOLUME, NO SUBMERGED VOLUME CALCULATION WILL BE CONSIDERED. THE DESIGN CASES TO BE CONSIDERED ARE PRESENTED ON THE NEXT. PAGE.

These calculations are furnished exclusively for use in connection with this project. The Reinforced Earth Company is exclusive licensee in the United States for Reinforced Earth covered under U.S. patents issued to Henri Vidal. These calculations contain information proprietary to the Reinforced Earth Company. Except as specifically authorized in writing by the Reinforced Earth Company, possession of these calculations does not authorize use of the patented or proprietary information contained therein, nor transmission to any other organization of the calculations or of information contained therein.

LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3085

SHEET 4 OF

SUBJECT: DESIGN CASES

DESG: dpm

CHKD: RA

DATE:

DESIGN CASE I

THIS CASE REPRESENTS THE MAXIMUM WATER LEVEL TO BE EXPERIENCED, DURING FULL PROBABLE MAXIMUM FLOOD (PMF.) THE WATER SURFACE IS ASSUMED TO BE EQUAL TO THE TOP OF THE WALL ELEVATION 6730.0 (±). DUE TO THE PRESENCE OF WATER TIGHT JOINTS ON THE UPSTREAM FACE, THE MATERIAL WITHIN THE R.E. VOLUME WILL REMAIN DRY.

DESIGN CASE II

THIS CASE REPRESENTS THE WATER SURFACE AT NORMAL POOL DEPTH AND CONSIDERS THE EARTH PRESSURES APPLIED BY WALL A ON WALL B AND CONVERSELY WALL B ON WALL A. SINCE BOTH MASSES ARE REINFORCED, PROPERTIES OF THE SOIL RELATED TO STRENGTH WILL EXHIBIT HIGHER VALUES. CALCULATIONS TO DETERMINE THE MAGNITUDE of THE INCREASED STRENGTH PARAMETERS (AN EQUIVALENT phi (Ø) ANGLE) ARE PRESENTED ON SHEET .

DESIGN CASE III

THIS CASE REPRESENTS WATER AT NORMAL POOL ELEVATION AND CONSIDERS A 0.47g SEISMIC ACCELERATION AND ITS EFFECTS ON THE STRUCTURE.

These calculations are furnished exclusively for use in connection with this project. The Reinforced Earth Company is exclusive licensee in the United States for Reinforced Earth covered under U.S. patents issued to Henri Vidal. These calculations contain information proprietary to the Reinforced Earth Company. Except as specifically authorized in writing by the Reinforced Earth Company, possession of these calculations does not authorize use of the patented or proprietary information contained therein, nor transmission to any other organization of the calculations or of information contained therein.

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3085

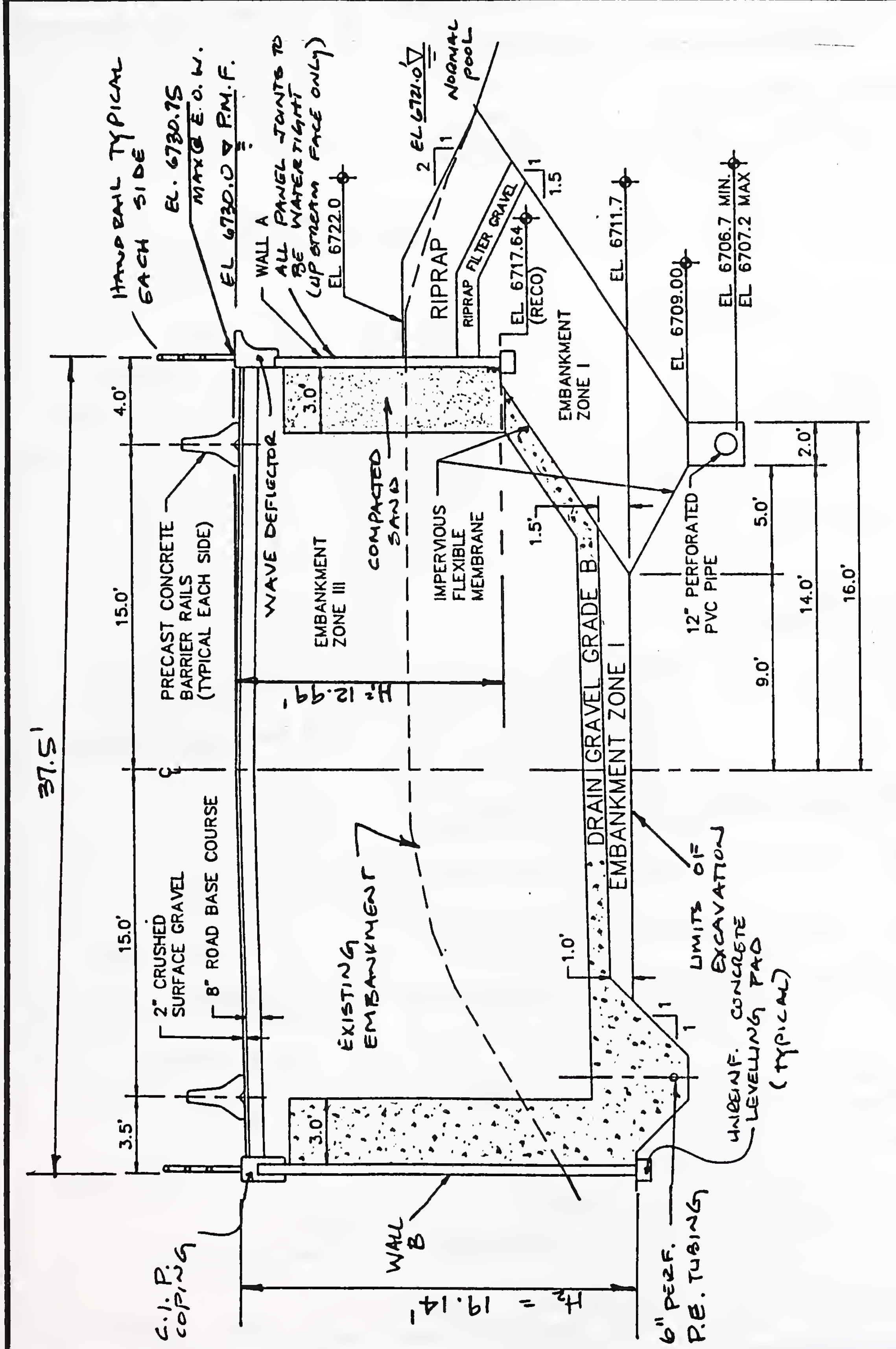
SHEET 5 OF

SUBJECT: TYPICAL SECTION

DESG: dpm

CHKD: PLA

DATE:


HANDRAIL TYPICAL EACH SIDE
EL. 6730.75 MAX @ E.O.W.
EL 6730.0 ▽ P.M.F.
WALL A
ALL PANEL JOINTS TO BE WATERTIGHT (UPSTREAM FACE ONLY)
EL 6722.0
EL 6721.0' ▽ NORMAL POOL
2
1
RIPRAP
RIPRAP FILTER GRAVEL
EL 6717.64 (RECO)
1
1.5
EL 6711.7
EL 6709.00
EL 6706.7 MIN.
EL 6707.2 MAX
EMBANKMENT ZONE I
4.0'
3.0'
WAVE DEFLECTOR
COMPACTED SAND
IMPERVIOUS FLEXIBLE MEMBRANE
1.5'
2.0'
5.0'
14.0'
16.0'
9.0'
12" PERFORATED PVC PIPE
PRECAST CONCRETE BARRIER RAILS (TYPICAL EACH SIDE)
15.0'
EMBANKMENT ZONE III
H₁ 12.99'
DRAIN GRAVEL GRADE B
EMBANKMENT ZONE I
37.5'
℄
8" ROAD BASE COURSE
2" CRUSHED SURFACE GRAVEL
15.0'
EXISTING EMBANKMENT
LIMITS OF EXCAVATION
1.0'
1
1
UNREINF. CONCRETE LEVELLING PAD (TYPICAL)
3.5'
3.0'
WALL B
C.I.P. COPING
H₂ = 19.14'
6" PERF. P.E. TUBING

TYPICAL SECTION
REINFORCED EARTH STRUCTURE

STRIP LENGTHS AND LOCATIONS NOT SHOWN FOR CLARITY

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA
PROJECT NO: 3085
SHEET 6 OF
SUBJECT: DESIGN PARAMETERS
DESG: dpm
CHKD: RLA
DATE:

MATERIAL PROPERTIES

REINFORCING STRIPS

50 × 4 MM WITH 9/16" Φ BOLT HOLE

A-572, $F_y = 65$ ksi (MIN.)

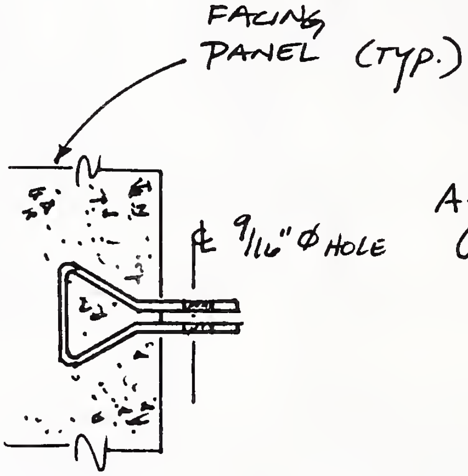
$A_g = 0.310 \text{ in}^2$ $A_{NET} = 0.221 \text{ in}^2$

TIE STRIPS

50 MM × 11 GAUGE

WITH 9/16" Φ BOLT HOLE

$A_g = 0.471 \text{ in}^2$ $A_{NET} = 0.336 \text{ in}^2$



A-570 STEEL
(GRADE 50)
$F_y = 50$ ksi (MIN)

CONCRETE PANELS

5½" THICK, $f'_c = 4{,}000$ psi @ 28 DAYS (MINIMUM), $f_y = 60{,}000$ psi (GRADE 60 REBAR)

*SOIL PROPERTIES USED FOR DESIGN

ϕ_{RE} (SOIL FRICTION ANGLE R.E. BACKFILL) = 34°

γ_{RE} (UNIT WEIGHT OF R.E. BACKFILL) = 125 pcf

COEFFICIENTS OF EARTH PRESSURE } K_o (at REST) = 0.44
K_a (ACTIVE) = 0.28

MAXIMUM VALUE OF APPARENT COEFFICIENT OF FRICTION } = 2.0

COEFFICIENT OF FRICTION @ FOUNDATION } = TAN 30°

STRESS AT CONNECTION = 100% OF MAXIMUM TIE TENSION (SIMPLICITY OF CALCULATION - CONSERVATIVE)

* FOR DEFINITION OF MATERIAL REFER TO THE TECHNICAL SPECIFICATIONS FOR THE REINFORCED EARTH WALLS FOR THIS PROJECT.

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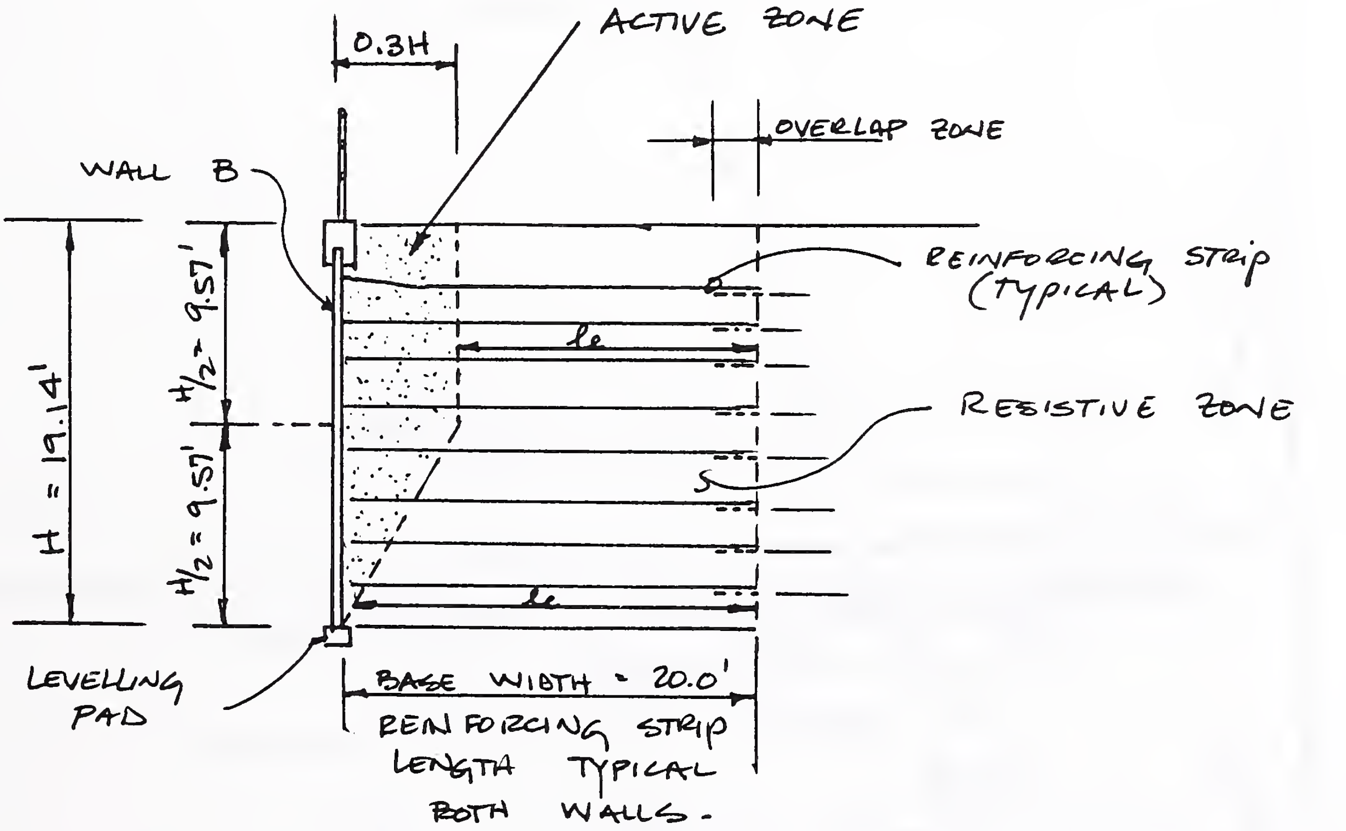
LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA
PROJECT NO: 3085
SHEET 7 OF
SUBJECT: REINFORCING STRIP. EFFECTIVE LENGTH.
DESG: dpm
CHKD: PLA
DATE:

EFFECTIVE LENGTH of REINFORCING STRIPS (le)

THE EFFECTIVE LENGTH OF THE REINFORCING STRIPS IS THE LENGTH AVAILABLE FOR FRICTION, LOCATED IN THE RESISTIVE ZONE. (HEIGHT SHOWN FOR WALL B).


0.3H
ACTIVE ZONE
OVERLAP ZONE
WALL B
REINFORCING STRIP (TYPICAL)
le
H = 19.14'
H/2 = 9.57'
H/2 = 9.57'
RESISTIVE ZONE
le
LEVELLING PAD
BASE WIDTH = 20.0'
REINFORCING STRIP LENGTH TYPICAL BOTH WALLS.

le = BASE WIDTH − 0.3H FOR DEPTH ≤ H/2

"OR"

le = BASE WIDTH − 0.6 (H − R.S. LEVEL) FOR DEPTH > H/2

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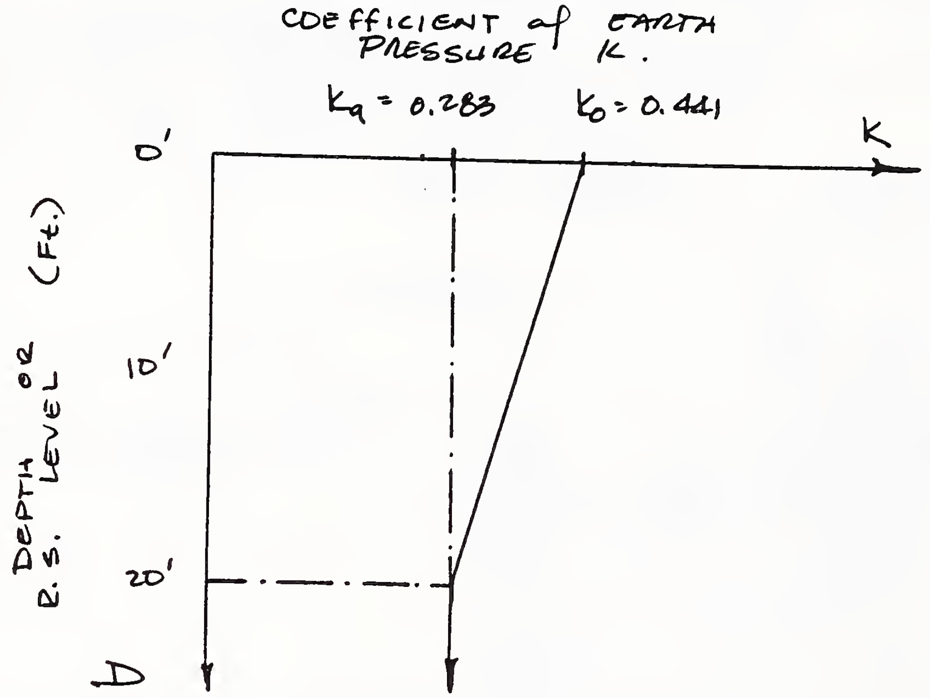
The Reinforced Earth Company
Corporate Headquarters • Arlington, Virginia
Western Division
2710 Gateway Oaks Drive, Suite 215 - South
Sacramento, CA 95833
(916) 649-9991

LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA
PROJECT NO: 3085
SHEET 8 OF
SUBJECT: COEFFICIENTS FOR DESIGN
DESG: dpm
CHKD: PLA
DATE:

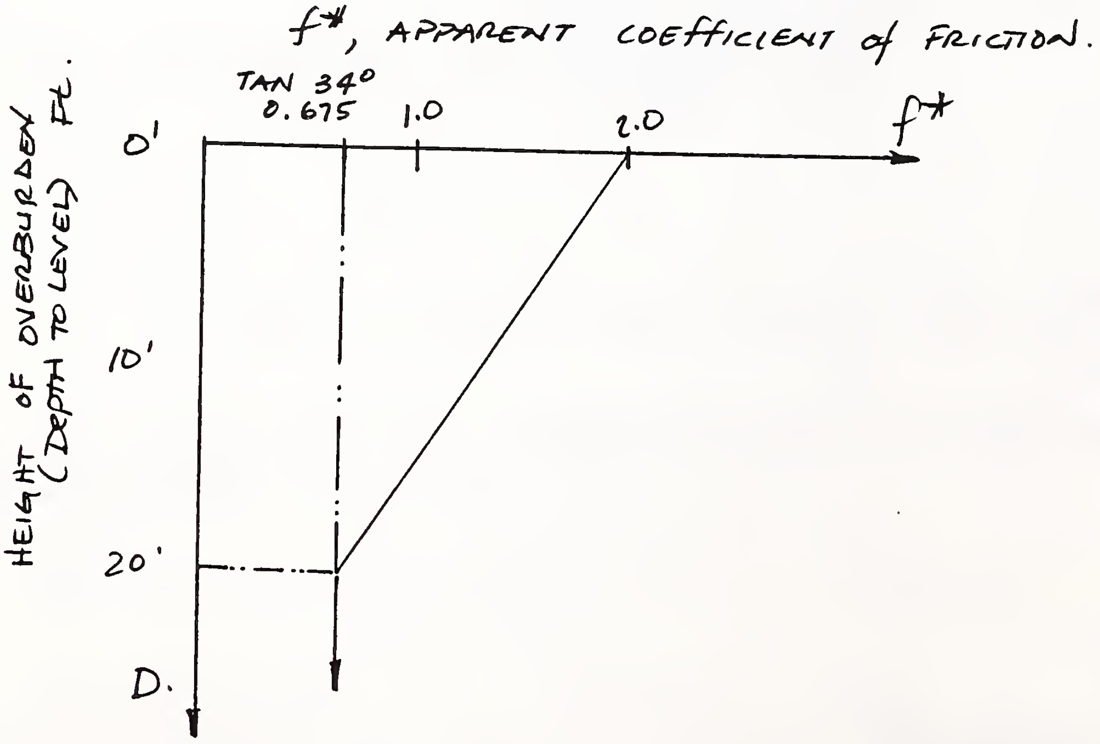
COEFFICIENT of EARTH PRESSURE, K VS. DEPTH (R. S. LEVEL)

$\Phi_{RE} = 34^0$



APPARENT COEFFICIENT OF FRICTION

f* VS. OVERBURDEN D



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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3085

SHEET 9 OF

SUBJECT: DESIGN CASE I

DESG: dpm CHKD: PLA DATE:

DESIGN CASE I

(FULL P.M.F. ACTING ON STRUCTURE)

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3085

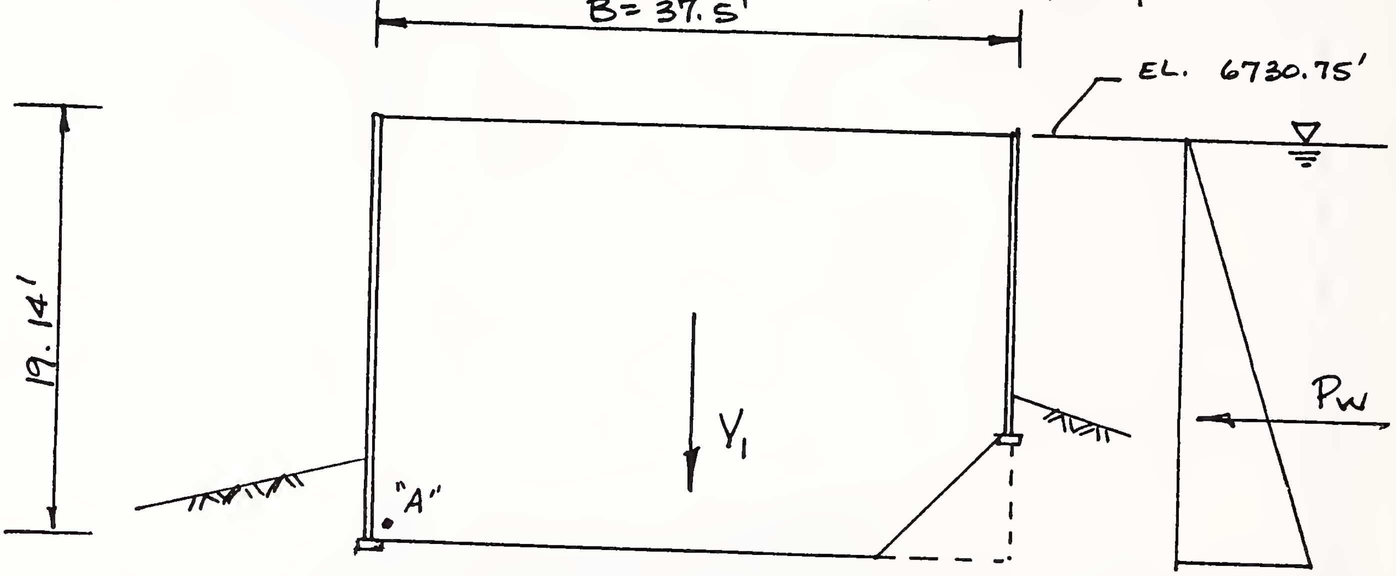
SHEET 10 OF

SUBJECT: DESIGN CASE I

DESG: dpm CHKD: PLA

DATE:

DESIGN CASE I - FULL P.M.F. - WATER @ 6730.75 (CONSERVATIVE)
WATER TO MAXIMUM WALL HEIGHT w/ COPING TAPER.



DESIGN SKETCH
NOT TO SCALE

EXTERNAL STABILITY

VERTICAL LOAD AND RESISTING MOMENT ABOUT POINT "A"

$Y_1 = 0.125^{kcf} \times 19.14' \times 37.5' = 89.72^{k}$ | $M_R = 89.72^{k} \times \frac{37.5'}{2} = 1682.23^{k\text{-}Ft}$

HORIZONTAL FORCE AND OVERTURNING MOMENT ABOUT POINT "A"

$P_W = 0.0624^{kcF} \times (19.14)^2 \times 0.5 = 11.43^{k}$ | $M_O = 11.43^{k} \times \frac{19.14'}{3} = 72.92^{k\text{-}Ft}$

COMPUTE SAFETY FACTOR AGAINST SLIDING ALONG BASE

$SF_S = \frac{\Sigma V}{\Sigma H} \times \tan\phi_{MIN} = \frac{89.72^{k}}{11.43^{k}} \times \tan 30° = \boxed{4.19} \gg 1.5$ ok

COMPUTE SAFETY FACTOR AGAINST OVERTURNING ABOUT POINT "A"

$SF_O = \frac{\Sigma M_R}{\Sigma M_O} = \frac{1682.23^{k\text{-}Ft}}{72.92^{k\text{-}Ft}} = \boxed{23.07} \gg 2.0$ ok

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA
PROJECT NO: 3085
SHEET 11 OF
SUBJECT: DESIGN CASE I
DESG: dpm
CHKD: PLA
DATE:

COMPUTE ECCENTRICITY OF REINFORCED EARTH STRUCTURE

$$e = \frac{B}{2} - \left[\frac{\Sigma M_e - \Sigma M_o}{\Sigma V}\right] = \frac{37.5'}{2} - \left[\frac{1682.23^{k\text{-}ft} - 72.92^{k\text{-}ft}}{89.72^{k}}\right]$$

$$e = 0.81' \ll B/6 = 6.25 \quad \underline{ok}$$

COMPUTE BEARING PRESSURE @ BASE OF WALL
(MEYERHOF'S EQUATION)

$$q_v = \frac{\Sigma V}{B-2e} = \frac{89.72^{k}}{37.5 - (2)(.81')} = \boxed{2.50^{ksf}}$$

NOTE:

THE BEARING PRESSURE COMPUTED ABOVE SHOULD BE CHECKED AGAINST THE STATIC ANALYSIS WHICH CONSIDERS ONE WALL LOADING ANOTHER. (SEE DESIGN CASE II)

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LOCATION: MIDDLE CREEK DAM
BOZEMAN MONTANA

PROJECT NO: 3085

SHEET 12 OF

SUBJECT: DESIGN CASE I

DESG: dpm CHKD: PLA

DATE:

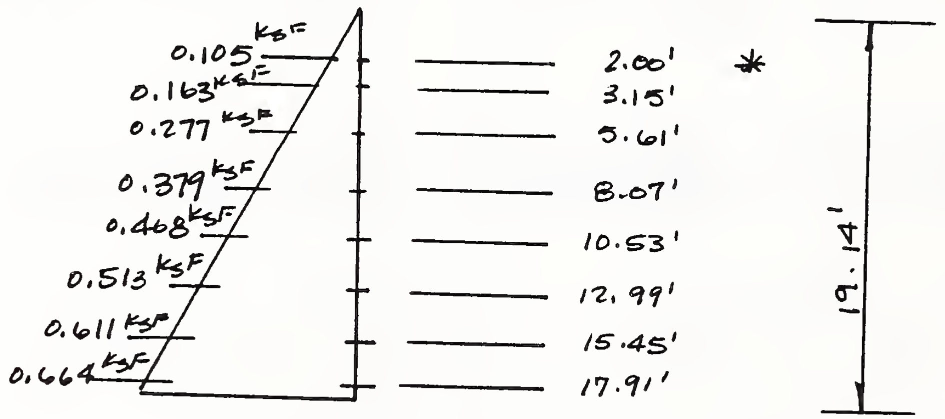
INTERNAL STABILITY - EARTH PRESSURE DIAGRAM.

SINCE ECCENTRICITY IS SO SMALL, $\sigma_{h\ \text{ANY LEVEL}} = \gamma H K = \overset{\text{kcf}}{0.125} \times h \times k.$

R.S. LEVEL

σ_h @ R.S. LEVEL.

R.S. LEVEL.



EARTH PRESSURE DIAGRAM.
N.T.S.

INTERNAL DESIGN SUMMARY CHART (STATIC ONLY)

* TOP LEVEL BENT DOWN TO 2.00' TO ACHIEVE OVERBURDEN FOR SEISMIC (MEASURED FROM TOP OF GRAVEL)

R.S. LEVEL	E.P. σ_h (KSF)	AREA OF PANEL (SF)	FORCE TO BE RESISTED $\sigma_h \times A_p = P$	h_{SOIL}	f^*	EFFECTIVE LENGTH l_e	N # R.S.	AVAIL. RESIST. T	S.F. T/P
2.00'	0.105	21.55	2.26 K	2.00'	1.87	14.26	4	8.75 K	3.87
3.15'	0.163	21.55	3.51 K	3.15'	1.79	14.26	4	13.19 K	3.76
5.61'	0.277	24.2	6.70 K	5.61'	1.63	14.26	4	21.39 K	3.19
8.07'	0.379	24.2	9.17 K	8.07'	1.46	14.26	4	27.56 K	3.01
10.53'	0.468	24.2	11.33 K	10.53'	1.30	14.83	4	33.30 K	2.94
12.99'	0.513	24.2	12.41 K	12.99'	1.13	16.31	4	39.28 K	3.17
15.45'	0.611	24.2	14.79 K	15.45'	0.97	17.82	4	43.81 K	2.96
17.91'	0.664	24.2	16.07 K	17.91'	0.81	19.26	4	45.84 K	2.85

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3085

SHEET 13 OF

SUBJECT: DESIGN CASE I

DESG: dpm

CHKD: PLA

DATE:

COMPUTE MAXIMUM REINFORCING STRIP STRESS

$$f_t = \frac{\sigma h_{max} \times A_p}{N \times A_{\substack{NET \\ STRIP}}} = \frac{0.664^{KSF} \times 24.2_{SF}}{4 \times 0.221\, IN^2}$$

$$f_t = \boxed{18.18^{ksi}} < 40^{ksi} \quad \underline{ok}$$

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3035

SHEET 14 OF

SUBJECT: DESIGN CASE II

DESG: dpm CHKD: RLA DATE:

DESIGN CASE II

(STATIC ANALYSIS)

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3085

SHEET 15 OF

SUBJECT: EQUIVALENT Ø FOR BACK TO BACK REINF. EARTH WALLS

DESG: dpm

CHKD: RLA

DATE:

DISCUSSION STATIC ANALYSIS

BASED ON RESEARCH AND EXPERIENCE, THE MAGNITUDE OF APPLIED EARTH PRESSURE, RESULTING FROM PLACEMENT OF REINFORCED EARTH WALLS, BACK TO BACK CAN BE TAKEN AS 75% OF THE VALUE CALCULATED FOR A LEVEL SURCHARGE CONDITION, FOR A STANDARD REINFORCED EARTH WALL. THIS REDUCTION IN MAGNITUDE CAN BE ATTRIBUTED TO THE PRESENCE OF THE REINFORCING STRIPS AND THEIR APPARENT POSITIVE EFFECT ON THE STRENGTH PARAMETERS OF THE SOIL. IN ORDER TO UTILIZE A COMPUTER ANALYSIS OF THE WALLS IT WILL BE NECESSARY TO CALCULATE AN EQUIVALENT PHI ANGLE (ϕ_{eq}) TAKING INTO CONSIDERATION THE INCREASED STRENGTH OF THE REINFORCED SOIL BEHIND THE VOLUME. THE PHI ANGLE IS DETERMINED BELOW.

$$0.75\left[\cancel{\tfrac{1}{2}}\,\cancel{\gamma}\,\cancel{H}\,Ka_{34^\circ}\right] = \cancel{\tfrac{1}{2}}\,\cancel{\gamma}\,\cancel{H}\,Ka_{RANDOM}$$

$$0.75\,Ka_{34^\circ} = Ka_{RANDOM} \longrightarrow 0.283 \times 0.75 = 0.212 = Ka_{RANDOM}.$$

$$Ka_{RANDOM} = \tan^2\left(45 - \phi_{eq}/2\right) \Rightarrow 0.212 = \tan^2\left(45 - \frac{\phi_{eq}}{2}\right)$$

$$\tan^{-1}\left(\sqrt{0.212}\right) = 45 - \frac{\phi_{eq}}{2}$$

$$24.736^\circ = 45 - \frac{\phi_{eq}}{2}$$

$$\phi_{eq_{RANDOM}} = 40.528^\circ \longrightarrow \text{SAY } \boxed{40^\circ}$$

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JOB NUMBER : 3085 DATE : 02-Oct-89 PREPARED BY : dpm
JOB NAME : MIDDLE CREEK DAM CHECKED BY: PLA
COMMENTS : STATIC ANALYSIS DESIGN CASE II

REINFORCED EARTH WALL DESIGN CALCULATIONS
CONCRETE FACING ELEMENT

INPUT VERIFICATION

MATERIAL PROPERTIES

REINFORCING STRIPS (A-572)	Fy = 65.0 KSI	Ft - AASHTO 1983 Sect. 10.32.3.1
CONCRETE	F'c = 4,000 PSI	

GEOMETRY

HEIGHT OF WALL = H FT.
THEORETICAL HEIGHT = H' FT.
STRIP LENGTH = B FT.

SOIL PROPERTIES

PHI ANGLE		COEFF OF E.P. ACTIVE	@ REST	UNIT WEIGHT
PHI R.E. MATERIAL =	34 DEGREES	.28	.44	.125 K / CU.FT.
PHI RANDOM FILL =	40 DEGREES (AS NOTED)		N.A.	.125 K / CU.FT.

↑ REFER TO SHEET 15 FOR EQUIVALENT φ DETERMINATION

EQUIVALENT HEIGHT OF SOIL FOR TRAFFIC SURCHARGE = (AS NOTED)
DEPTH AT WHICH BOND COEFFICIENT = TANGENT OF PHI = 20 FT.
MAXIMUM VALUE OF APPARENT COEFFICIENT OF FRICTION (BOND) = 2
COEFFICIENT OF FRICTION AT FOUNDATION LEVEL (SLIDING) = .577
SURFACE AREA OF ONE PANEL = 4.92 X 4.92 = 24.2 SQ. FT.

STRESS AT CONNECTION = 100 % OF MAXIMUM TIE TENSION TO A DEPTH OF .6H'
INCREASING TO 100% AT THE TOE OF WALL

DESIGN CASE II - WALL B

```
JOB NUMBER : 3085

                  MASS STABILITY AND MAXIMUM BEARING PRESSURE
                ( H = 19.14 FT. ,   H' = 19.14 FT. ,   B = 20 FT. )
                                MASS STABILITY

        LOAD                    MOMENT ARM                  MOMENT

   VERTICAL LOADS
     47.85 KIPS                10.00 FEET                478.50 K-FT.
  --------------                                    -----------------
     47.85 KIPS                                          478.50 K-FT.

   HORIZONTAL LOADS
      4.98 KIPS                 6.38 FEET                 31.76 K-FT.
      1.04 KIPS                 9.57 FEET                  9.96 K-FT.
  --------------                                    -----------------
      6.02 KIPS                                           41.72 K-FT.

 SAFETY FACTOR AGAINST OVERTURNING = 11.47
 SAFETY FACTOR AGAINST SLIDING = 4.59

                          MAXIMUM BEARING PRESSURE
                            LEVEL H = 19.14 FT.

        LOAD                    MOMENT ARM                  MOMENT

   VERTICAL LOADS
     47.85 KIPS                 0.00 FEET                  0.00 K-FT.
      5.00 KIPS                 0.00 FEET                  0.00 K-FT.
  --------------                                    -----------------
     52.85 KIPS                                            0.00 K-FT.

   HORIZONTAL LOADS
      4.98 KIPS                 6.38 FEET                 31.76 K-FT.
      1.04 KIPS                 9.57 FEET                  9.96 K-FT.
  --------------                                    -----------------
      6.02 KIPS                                           41.72 K-FT.

 BEARING PRESSURE AT TOE OF WALL = 2.87 KSF
 ECCENTRICITY =  .79 FT. < B/6 = 3.33 FT.     OK

 DESIGN TYPE = LEVEL SURCHARGE
 COEFF. OF EARTH PRESSURE (RANDOM FILL) = .22
 EQUIVALENT HEIGHT OF SOIL FOR TRAFFIC SURCHARGE = 2 FEET ( .25 KSF)
```

— MAXIMUM BEARING PRESSURE APPLIED

JOB NUMBER : 3085 – DESIGN CASE II – WALL B

REINFORCED EARTH WALL DESIGN SUMMARY
(H = 19.14 FT. , H' = 19.14 FT. , B = 20 FT.)

LEVEL	MAX. HORIZ. STRESS (KSF)	STRESS @ FACING (KSF)	DENSITY	REINF. STRIP STRESS (KSI)	HORIZ. STRESS (BOND) (KSF)	EFFECT. LENGTH S.F.
* 2.00' ~~1.23'~~	0.17	0.17	4-50X4 MM	4.65	0.07	~~3.26~~ 5.15
3.15'	0.27	0.27	4-50X4 MM	7.38	0.16	3.41
5.61'	0.38	0.38	4-50X4 MM	10.39	0.28	3.15
8.07'	0.48	0.48	4-50X4 MM	13.12	0.39	2.93
10.53'	0.58	0.58	4-50X4 MM	15.85	0.49	2.81
12.99'	0.66	0.66	4-50X4 MM	18.04	0.57	2.87
15.45'	0.73	0.73	4-50X4 MM	19.95	0.65	2.80
17.91'	0.80	0.80	4-50X4 MM	21.87	0.73	2.60

DESIGN TYPE = LEVEL SURCHARGE
COEFF. OF EARTH PRESSURE (RANDOM FILL) = .22
EQUIVALENT HEIGHT OF SOIL FOR TRAFFIC SURCHARGE = 2 FEET (.25 KSF)

* Bend reinforcing strip down to level 2.00' to achieve required overburden for seismic.

$$SF\ 2.0 = \frac{f^{*}2.0}{f^{*}1.23} \times \frac{h\ 2.0}{h\ 1.23} \times SF\ 1.23$$

$$SF_{2.0} = \underbrace{\frac{1.87}{1.92} \times \frac{2.00'}{1.23'}}_{1.58} \times 3.26 = 5.15$$

** DESIGN CASE III (STATIC + DYNAMIC)
CONTROLS INTERNAL STRESSES SEE SHEET 25.

```
JOB NUMBER : 3085   DESIGN CASE II  -  WALL A

                MASS STABILITY AND MAXIMUM BEARING PRESSURE
               ( H = 12.99 FT. ,   H' = 12.99 FT. ,   B = 20 FT. )
                               MASS STABILITY

          LOAD                   MOMENT ARM                MOMENT

     VERTICAL LOADS
       32.48 KIPS                10.00 FEET               324.75 K-FT.
   --------------                                     -----------------
       32.48 KIPS                                         324.75 K-FT.

     HORIZONTAL LOADS
         2.29 KIPS                4.33 FEET                  9.93 K-FT.
         0.71 KIPS                6.50 FEET                  4.59 K-FT.
   --------------                                     -----------------
        3.00 KIPS                                           14.52 K-FT.

SAFETY FACTOR AGAINST OVERTURNING = 22.37
SAFETY FACTOR AGAINST SLIDING = 6.25

                       MAXIMUM BEARING PRESSURE
                          LEVEL H = 12.99 FT.

          LOAD                   MOMENT ARM                MOMENT

     VERTICAL LOADS
       32.48 KIPS                0.00 FEET                  0.00 K-FT.
        5.00 KIPS                0.00 FEET                  0.00 K-FT.
   --------------                                     -----------------
       37.48 KIPS                                           0.00 K-FT.

     HORIZONTAL LOADS
        2.29 KIPS                4.33 FEET                  9.93 K-FT.
        0.71 KIPS                6.50 FEET                  4.59 K-FT.
   --------------                                     -----------------
        3.00 KIPS                                          14.52 K-FT.

BEARING PRESSURE AT TOE OF WALL = 1.95 KSF
ECCENTRICITY =   .39 FT. < B/6 = 3.33 FT.     OK

DESIGN TYPE = LEVEL SURCHARGE
COEFF. OF EARTH PRESSURE (RANDOM FILL) = .22
EQUIVALENT HEIGHT OF SOIL FOR TRAFFIC SURCHARGE = 2 FEET ( .25 KSF)
```

JOB NUMBER : 3085 DESIGN CASE II - WALL A

REINFORCED EARTH WALL DESIGN SUMMARY
(H = 12.99 FT. , H' = 12.99 FT. , B = 20 FT.)

LEVEL	MAX. HORIZ. STRESS (KSF)	STRESS @ FACING (KSF)	DENSITY	REINF. STRIP STRESS (KSI)	HORIZ. STRESS (BOND) (KSF)	EFFECT. LENGTH S.F.
* 2.00 ~~1.23'~~	0.17	0.17	4-50X4 MM	4.65	0.07	~~3.68~~ 5.81'
4.38'	0.33	0.33	4-50X4 MM	9.02	0.22	3.71
6.84'	0.43	0.43	4-50X4 MM	11.75	0.34	3.44
9.30'	0.53	0.53	4-50X4 MM	14.49	0.44	3.53
11.76'	0.62	0.62	4-50X4 MM	16.95	0.53	3.54

DESIGN TYPE = LEVEL SURCHARGE
COEFF. OF EARTH PRESSURE (RANDOM FILL) = .22
EQUIVALENT HEIGHT OF SOIL FOR TRAFFIC SURCHARGE = 2 FEET (.25 KSF)

* Bend reinforcing strip down to level 2.00' to achieve required overburden for seismic.

$$SF\ 2.0 = \frac{f^*2.0}{f^*1.23} \times \frac{h\ 2.0}{h\ 1.23} \times SF\ 1.23$$

$$SF_{2.0} = 1.58 \times 3.68 = 5.81$$

see sheet 18

** DESIGN CASE III CONTROLS INTERNAL STRESSES SEE SHEET 27.

LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3085

SHEET 21 OF

SUBJECT: DESIGN CASE III

DESG: dpm

CHKD: PLA

DATE:

DESIGN CASE III

(STATIC + DYNAMIC ANALYSIS)

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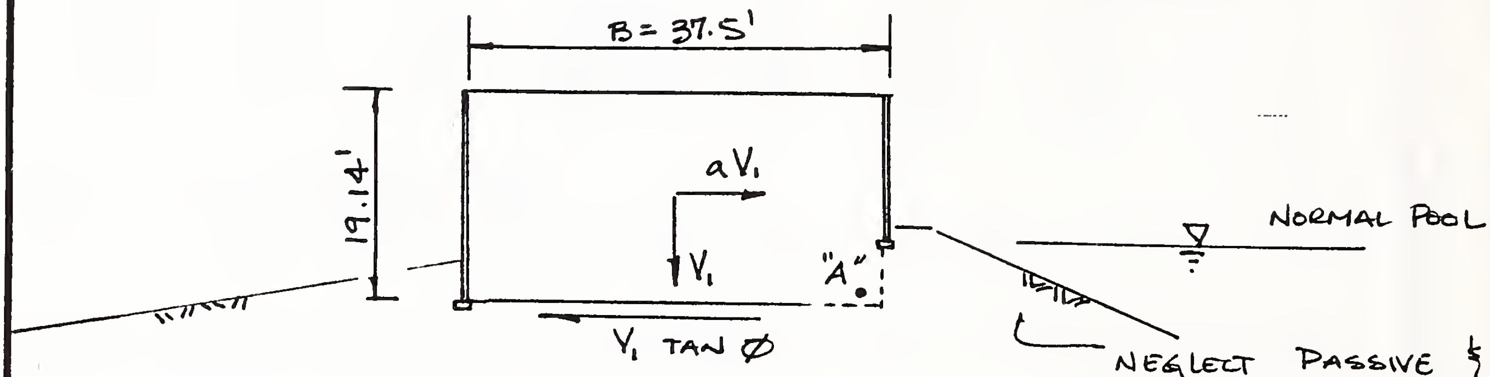
LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA
PROJECT NO: 3085
SHEET 22 OF
SUBJECT: DESIGN CASE III
DESG: dpm
CHKD: PLA
DATE:

EXTERNAL STABILITY OF ENTIRE STRUCTURE

$a = 0.47g$
SEISMIC CONDITION.



NEGLECT PASSIVE & ACTIVE PRESSURE OF EMBANKMENT.

SAFETY FACTOR AGAINST SLIDING ALONG BASE

$$SF_s = \frac{\Sigma V \times \tan \phi}{\Sigma H} = \frac{\cancel{V_1} \times \tan 30^\circ}{\cancel{V_1} \times 0.47g} = \frac{0.577}{0.47} = \boxed{1.23} > 1.0 \quad \underline{\underline{ok}}$$

SAFETY FACTOR AGAINST OVERTURNING ABOUT POINT "A"

$$SF_o = \frac{\Sigma M_R}{\Sigma M_o} = \frac{\cancel{V_1} \times B/2}{0.47\cancel{V_1} \times H/2} = \frac{\frac{37.5'}{2}}{0.47 \times \frac{19.14}{2}} = \boxed{4.17} \gg 1.0 \quad \underline{\underline{ok}}$$

ECCENTRICITY AND BEARING PRESSURE:

ECCENTRICITY AND BEARING PRESSURE ARE NOT CALCULATED BECAUSE OF THE FOLLOWING:

- THE LOADING CONDITION IS CYCLIC AND OF SHORT PERIOD
- THE REINFORCED EARTH STRUCTURE IS FLEXIBLE.

THEREFORE, THE BEARING PRESSURE AT THE BASE OF THE STRUCTURE SHOULD BE NO GREATER THAN THAT ACHIEVED IN THE STATIC CONDITION
(REFER TO SHEET 17.)

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3085

SHEET 23 OF

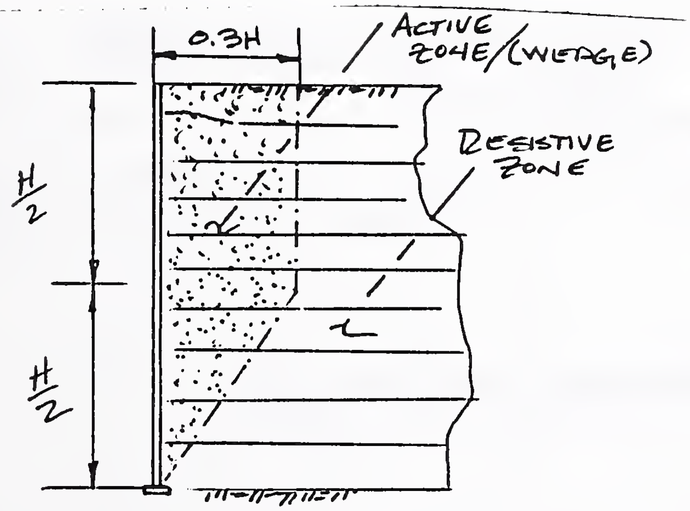
SUBJECT: DESIGN CASE III

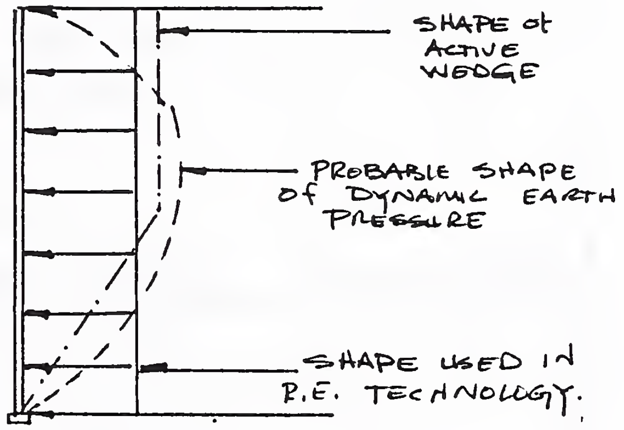
DESG: dpm

CHKD: PLA

DATE:

DEVELOPMENT OF EARTH PRESSURE DIAGRAMS FOR INTERNAL STABILITY DURING SEISMIC




SHAPE of ACTIVE WEDGE
PROBABLE SHAPE of DYNAMIC EARTH PRESSURE
SHAPE USED IN R.E. TECHNOLOGY.

WEIGHT of ACTIVE WEDGE (W)

$$W = 0.3H \times H \times 0.75 \times \gamma$$

RESULTANT HORIZONTAL FORCE w/ a = 0.47g

$$P_{EQ} = W \times 0.47g$$

RESULTANT RECTANGULAR EARTH PRESSURE DIAGRAM

$$\Delta\sigma_{H_{EQ}} = \frac{P_{EQ}}{H.}$$

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA
PROJECT NO: 3085
SHEET 24 OF
SUBJECT: DESIGN CASE III
DESG: dpM
CHKD: FLA
DATE:

COMPUTE EARTH PRESSURE DISTRIBUTION (STATIC + DYNAMIC)

(WALL B) DESIGN HEIGHT = 19.14'

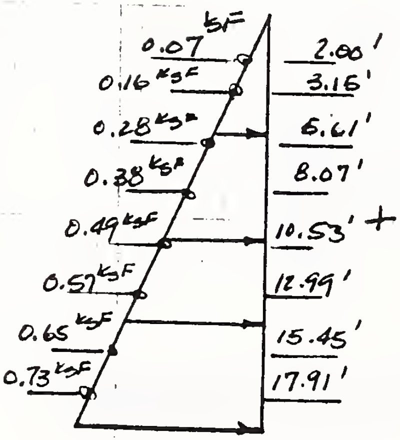
WEIGHT OF ACTIVE WEDGE

$$W = 0.3 \times (19.14') \times 19.14' \times 0.75 \times 0.125^{kcF} = 10.30^{k}$$

RESULTANT HORIZONTAL FORCE

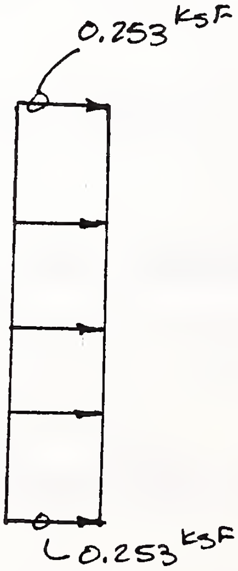
$$P_{eq} = 10.30^{k} \times 0.47 = 4.84^{k} \quad \therefore \Delta\sigma h_{EQ} = \frac{4.84^{k}}{19.14'} = \boxed{0.253^{ksF}}$$

RESULTANT EARTH PRESSURE DIAGRAMS


0.07 ksF
0.16 ksF
0.28 ksF
0.38 ksF
0.49 ksF
0.57 ksF
0.65 ksF
0.73 ksF
2.00'
3.16'
6.61'
8.07'
10.53'
12.99'
15.45'
17.91'

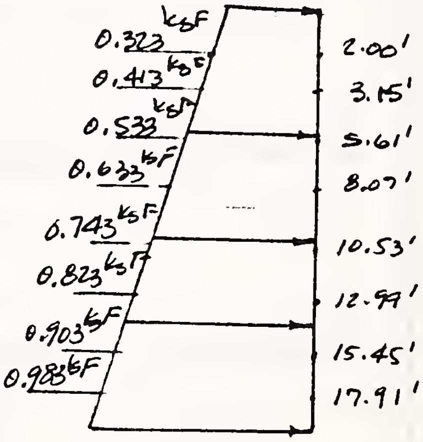
* STATIC EARTH PRESSURE DIAGRAM

+


0.253 ksF
0.253 ksF

DYNAMIC EARTH PRESSURE DIAGRAM

=


0.323 ksF
0.413 ksF
0.533 ksF
0.633 ksF
0.743 ksF
0.823 ksF
0.903 ksF
0.983 ksF
2.00'
3.15'
5.61'
8.07'
10.53'
12.99'
15.45'
17.91'

STATIC + DYNAMIC EARTH PRESSURE DIAGRAM

* REFER TO SHEET 18 COMPUTER DESIGN SUMMARY ON FOR STATIC PRESSURES.

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3085

SHEET 25 OF

SUBJECT: DESIGN CASE III

DESG: dpm

CHKD: DLA

DATE:

INTERNAL STABILITY DESIGN SUMMARY TABLE (WALL B)

STATIC + DYNAMIC

R.S. LEVEL (Ft)	EARTH PRESSURE σ_h (KSF)	PANEL AREA AP (SF)	FORCE, P TO BE RESISTED (KIPS)	h height of OVERBURDEN (Ft)	f^*	Effect. Length (le)	N # of R.S.	AVAILABLE RESISTANCE T (KIPS)	SAFETY FACTOR BOND T/P
*2.00	0.323	21.55	6.96	2.00	1.87	14.26	4	8.75	1.26
3.15	0.413	21.55	8.90	3.15	1.79	14.26	4	13.19	1.48
5.61	0.533	24.2	12.90	5.61	1.63	14.26	4	21.39	1.66
8.07	0.633	24.2	15.32	8.07	1.46	14.26	4	27.56	1.80
10.53	0.743	24.2	17.98	10.53	1.30	14.83	4	33.30	1.85
12.99	0.823	24.2	19.92	12.99	1.13	16.31	4	39.28	1.97
15.45	0.903	24.2	21.85	15.45	0.97	17.82	4	43.81	2.01
17.91	0.983	24.2	23.79	17.91	0.81	19.26	4	45.84	1.93

* BEND STRIP DOWN TO LEVEL 2.00' to ACHIEVE OVERBURDEN FOR SEISMIC

ALL SAFETY FACTORS ≥ 1.2 ok

MAXIMUM REINFORCING STRIP STRESS

$$f_t = \frac{0.983^{KSF} \times 24.2^{SF}}{4 \times 0.221_{IN^2}} = \boxed{26.91^{KSI}} < 40^{KSI} \quad \underline{\underline{ok}}$$

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA
PROJECT NO: 3085
SHEET 26 OF
SUBJECT: DESIGN CASE III
DESG: dpm CHKD: RA
DATE:

COMPUTE EARTH PRESSURE DISTRIBUTION

WALL A DESIGN HEIGHT = 12.99'

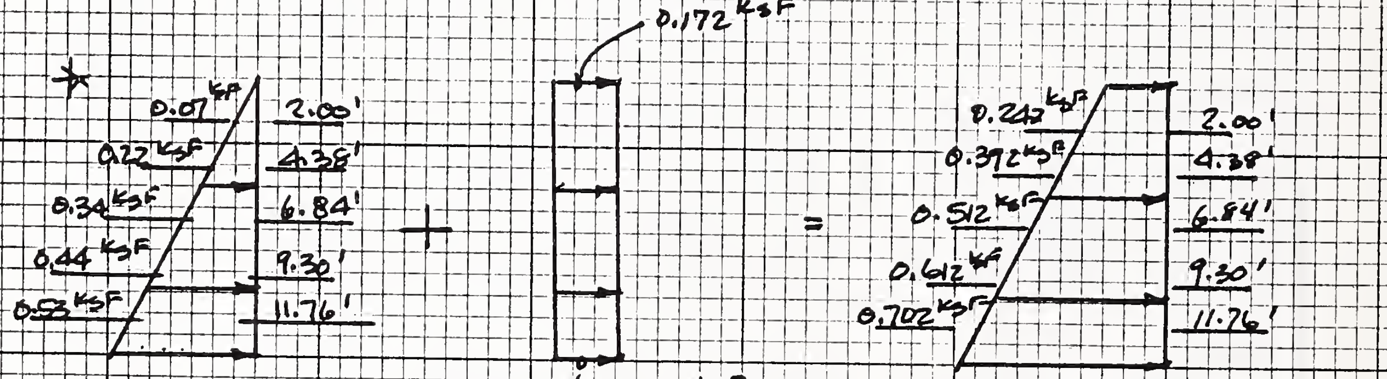
WEIGHT OF ACTIVE WEDGE

$W = 0.3 \times 12.99 \times 12.99 \times 0.75 \times 0.125^{kcf} = 4.75^{k}$

RESULTANT HORIZONTAL FORCE

$P_{eq} = 4.75^{k} \times 0.47 = 2.23^{k}$ $\therefore \Delta \sigma_{h_{EQ}} = \dfrac{2.23^{k}}{12.99'} = \boxed{0.172^{ksf}}$

RESULTANT EARTH PRESSURE DIAGRAMS



STATIC EARTH PRESSURE DIAGRAM

DYNAMIC EARTH PRESSURE DIAGRAM

STATIC + DYNAMIC EARTH PRESSURE DIAGRAM.

* REFER TO COMPUTER DESIGN SUMMARY ON SHEET 20 FOR STATIC PRESSURES.

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3085

SHEET 27 OF

SUBJECT: DESIGN CASE III

DESG: dpm CHKD: PLA DATE:

INTERNAL STABILITY DESIGN SUMMARY TABLE (WALL A)

STATIC + DYNAMIC

R.S. LEVEL (Ft)	EARTH PRESSURE σ_h (KSF)	PANEL AREA AP (SF)	FORCE, P TO BE RESISTED (kips)	HEIGHT OF OVERBURDEN h (Ft)	f^*	EFFECT. LENGTH (Ft)	N # of R.S.	AVAILABLE RESISTANCE T (kips)	SAFETY FACTOR BOND T/P
*2.00	0.242	27.60	6.68	2.00	1.87	16.10	4	9.88	1.48
4.38	0.392	27.60	10.82	4.38	1.71	16.10	4	19.78	1.83
6.84	0.512	24.2	12.39	6.84	1.55	16.31	4	28.37	2.29
9.30	0.612	24.2	14.81	9.30	1.38	17.79	4	37.46	2.53
11.76	0.702	24.2	16.99	11.76	1.22	19.26	4	45.33	2.67

* BEND TOP LEVEL OF STRIPS DOWN TO LEVEL 2.00 TO ACHIEVE OVERBURDEN FOR SEISMIC.

ALL SAFETY FACTORS ARE $\geq$ 1.2 ok

MAXIMUM REINFORCING STRIP STRESS

$$f_t = \frac{0.702 \times 24.2 \text{ SF}}{4 \times 0.221 \text{ in}^2} = \boxed{19.22^{\text{ksi}}} < 40^{\text{ksi}}$$ ok

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA
PROJECT NO: 3085
SHEET 28 OF 28
SUBJECT: SUMMARY.
DESG: dpm
CHKD: PLA
DATE:

SUMMARY.

THE DESIGN PRESENTED ON THE PRECEDING PAGES IS CONSERVATIVE FOR THE FOLLOWING REASONS:

1.) THE STRUCTURE HAS BEEN DESIGNED FOR EXTREME LOADING CONDITIONS.

CASE I – FULL P.M.F. HAVING A PROBABILITY OF OCCURANCE OF ONCE IN 10,000 years (±)

CASE III – 0.47g DYNAMIC CONDITION HAVING A LOW PROBABILITY OF OCCURANCE ALSO.

2.) EMBEDMENT AND CORRESPONDING PASSIVE EARTH PRESSURES HAVE BEEN NEGLECTED IN STABILITY CALCULATIONS

3.) A PEAK SEISMIC GROUND ACCELERATION OF $a = 0.47g$ WAS USED TO DESIGN THE SEISMIC CONDITION. AASHTO GUIDE SPECIFICATIONS FOR HIGHWAY BRIDGES 1983, SECTION 6.3.2 STATES "... FOR RETAINING WALLS WHICH MAY DISPLACE HORIZONTALLY WITHOUT SIGNIFICANT RESTRAINT, A SEISMIC COEFFICIENT EQUAL TO ONE-HALF THE ACCELERATION ($k_h = a/2$) IS RECOMMENDED..."

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Western Division
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Sacramento, CA 95833
(916) 649-9991

LOCATION:

PROJECT NO: 3085

SHEET 1 OF 5

SUBJECT: COVER SHEET

DESG: dpm

CHKD: GRH

DATE:

MONTANA

DEPARTMENT of NATURAL RESOURCES & CONSERVATION

MIDDLE CREEK DAM CREST RAISING

BOZEMAN, MONTANA

REINFORCED EARTH WALL DESIGN CALCULATIONS

SUPPLEMENTAL CALCULATIONS

RECo PROJECT NO. 3085

OCTOBER 10, 1990

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Western Division
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Sacramento, CA 95833
(916) 649-9991

LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3085

SHEET 2 OF

SUBJECT: SUPPLEMENTAL DESIGN CASE IV

DESG: dpm

CHKD: GRH

DATE:

DESIGN CASE IV

FULL PMF ACTING ON STRUCTURE
SATURATED BACKFILL

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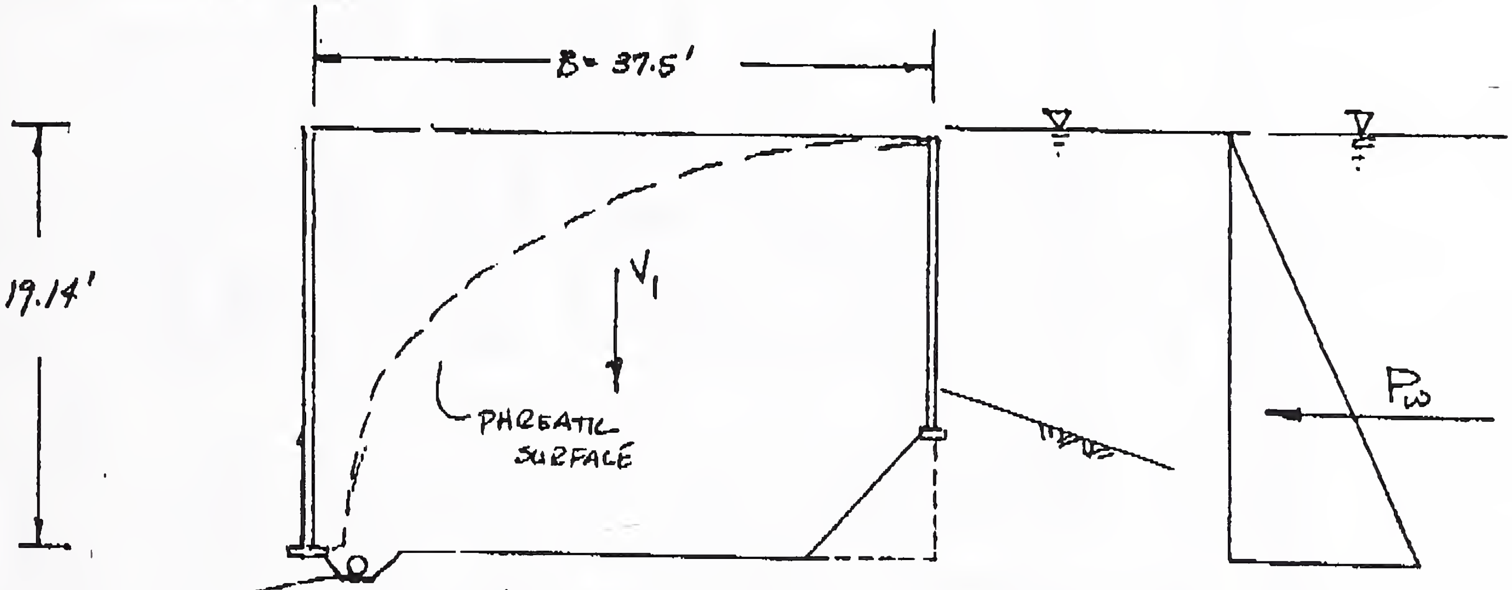
LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA
PROJECT NO: 3085
SHEET 3 OF
SUBJECT: DESIGN CASE IV
DESG: dpm
CHKD: GRH
DATE:

DESIGN CASE IV — FULL P.M.F. CONDITION W/ SATURATED BACKFILL



DESIGN SKETCH
NOT TO SCALE

VERTICAL LOAD AND RESISTING MOMENT

$$V_1 = (\underbrace{0.125^{kcf} - 0.0624^{kcf}}_{\gamma_{Buoy.}}) \times 19.14' \times 37.5' = 44.93^{k} \quad \Big\| \quad \times \frac{37.5'}{2} \overset{M_R}{=} 842.46^{k\text{-}ft}$$

HORIZONTAL FORCE AND OVERTURNING MOMENT

$$P_W = 0.0624^{kcf} \times (19.14)^2 \times 1/2 = 11.43^{k} \quad \Big\| \quad \times \frac{19.14'}{3} = 72.92^{k\text{-}ft}$$

COMPUTE SAFETY FACTOR AGAINST SLIDING ALONG BASE

$$SF_S = \frac{\Sigma V}{\Sigma H} \times 0.45 \Rightarrow \frac{44.93^{k}}{11.43^{k}} \times 0.45 = \boxed{1.77} > 1.13 \quad \text{ok}$$

← coefficient of friction (80% TAN φ)

(TEMP. CONDITION ie 3/4 × 1.5

COMPUTE SAFETY FACTOR AGAINST OVER TURNING.

$$SF_O = \frac{\Sigma M_R}{\Sigma M_O} = \frac{842.46^{k\text{-}ft}}{72.92^{k\text{-}ft}} = \boxed{11.55} \gg 1.5 \quad \text{ok}$$

↖ TEMPORARY CONDITION ie. 3/4 × 2.0

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA

PROJECT NO: 3085

SHEET 4 OF

SUBJECT: DESIGN CASE IV

DESG: dpm

CHKD: GRH

DATE:

INTERNAL DESIGN SUMMARY

FULL PMF SATURATED (BOUYANT) VOLUME

{ * MAXIMUM FORCES FROM DESIGN CASE I }

SATURATED (BOUYANT) VOLUME

R.S LEVEL	SOIL PRESSURE (KSF)	AREA of PANEL	Force to be Resisted P (K)	h_{soil} (BOUYANT)	f^* 85% × f^*_{dry}	EFFECTIVE LENGTH (le)	N # R.S.	AVAIL. RESISTANCE T	S.F. T/P
2.00'	0.105	21.55 SF	2.26 k	2.00'	1.59	14.26'	4	3.75 k	1.66
3.15'	0.163	21.55 SF	3.51 k	3.15'	1.52	14.26'	4	5.65 k	1.61
5.61'	0.277	24.2 SF	6.70 k	5.61'	1.39	14.26'	4	9.16 k	1.38
8.07'	0.379	24.2 SF	9.17 k	8.07'	1.24	14.26'	4	11.81 k	1.29
10.53'	0.468	24.2 SF	11.33 k	10.53'	1.11	14.83'	4	14.27 k	1.26
12.99'	0.513	24.2 SF	12.41 k	12.99'	0.96	16.31'	4	16.83 k	1.36
15.45'	0.611	24.2 SF	14.79 k	15.45'	0.83	17.82'	4	18.77 k	1.27
17.91'	0.664	24.2 SF	16.07 k	17.91'	0.69	19.26'	4	19.64 k	1.22

ALL SAFETY FACTORS IN BOND OR PULLOUT ARE GREATER THAN 1.2 OK FOR TEMPORARY CONDITION.

* FOR COMPUTATION OF VALUES REFER TO SHEETS 10 -13 OF PREVIOUSLY SUBMITTED CALCULATIONS DESIGN CASE I.

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LOCATION: MIDDLE CREEK DAM
BOZEMAN, MONTANA
PROJECT NO: 3085
SHEET 5 OF 5
SUBJECT: DESIGN CASE IV
DESG: JPM
CHKD: GRH
DATE:

DISCUSSION:

THE PREVIOUS ANALYSIS CONSIDERS THE LOADS APPLIED DURING A STATIC CONDITION WITH FULL P.M.F. WITH A VOLUME THAT IS BOUYANT REDUCING THE OVERBURDEN PRESSURE AND SUBSEQUENTLY THE RESISTANCE. WITH THE DRAINAGE SYSTEM DESIGN, THIS CONDITION, FULLY BOUYANT BACKFILL, IS NOT LIKELY TO OCCUR AND THEREFORE THESE CALCULATIONS ARE CONSERVATIVE.

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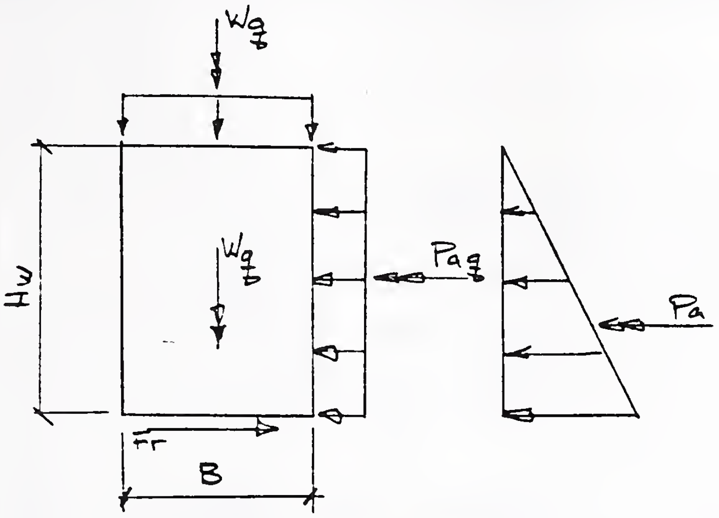
APPENDIX E-3
VSL RETAINED EARTH DESIGN DATA



RANKINE EXTERNAL ANALYSIS

$K_a = \frac{1 - \sin\phi}{1 + \sin\phi}$

$= \frac{1 - \sin 34}{1 + \sin 34}$

$= 0.283$

SOIL PARAMETERS:

γ = 125 pcf

ϕ = 34 deg (SELECT & RANDOM)

ϕ = 30 deg (BASE)

TRAFFIC = q = 250 psf

EARTHQUAKE = 0.47g

SATURATED CONDITIONS:

γ_w = 62.4 pcf

K_w = 1.0

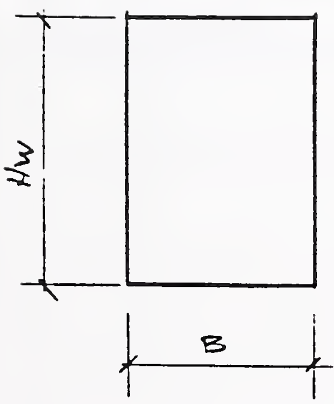
VOID RATIO = 0.1 (ASSUMED)

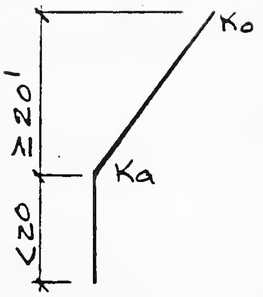
DRAWDOWN = N/A.

FACTORS OF SAFETY:

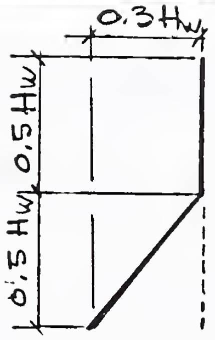
OVERTURNING	$\geq$ 2.00
SLIDING	$\geq$ 1.50
ECCENTRICITY	$\leq \frac{B}{6}$
PULLOUT	$\geq$ 1.50
STRESS	$\leq$ 0.55 *

* NOTE: $\frac{1}{3}$ OVERSTRESS ALLOWED DURING TRANSIENT LOADS

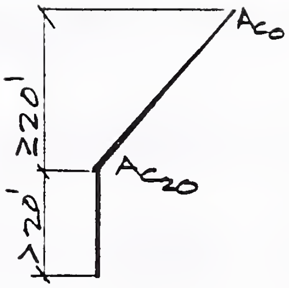




EARTH PRESSURE COEFFICIENT



FAILURE SURFACE **



ANCHORAGE FACTORS

$K_o = 1 - \sin\phi$

$= 1 - \sin 34$

$= 0.441$

$K_a = \frac{1 - \sin\phi}{1 + \sin\phi}$

$= \frac{1 - \sin 34}{1 + \sin 34}$

$= 0.283$

$F_H = \bar{z}_a * K * \frac{\sigma_{vb}}{H_W} * A_t$

$f_m = \frac{F_H}{A_b}$

$A_{c_0} = 40$

$A_{c_{20}} = 15$

$N = \text{INT}(B - 0.3H_W) + 1 \qquad z \leq \frac{H}{2}$

$N = \text{INT}[B - 0.6(H_W - z)] + 1 \qquad z > \frac{H}{2}$

$P_r = z * A_c * N * \gamma * (b*d)$

** NOTE: FAILURE SURFACE ASSUMED VERTICAL @ 0.2 H_W BEHIND WALL DUE TO LOW RESISTANCE IMPERMIABLE MATERIAL.

DATE 7-21-88	RETAINED EARTH™ WALL DESIGN CRITERIA	**VSL Corporation** Dallas — (214) 647-0200 Denver — (303) 779-1155 Houston — (713) 444-9045	PROJ. NO. 278-1334817
DES. BY			
DWN. BY	MIDDLE CREEK DAM		
CKD. BY			SHT 1 OF

$H_W = H_{MAX} = 19.40$ $\quad\quad$ $B = 14'$

$W_M = 19.40 * 14 * 138$

$= 37.48^K$

$M_{W_M} = 37.48 * \frac{14}{2}$

$= 262.36^{K\text{-}ft}$

$W_{\mathscr{Q}} = 14 * 250$

$= 3.50^K$

$M_{W_{\mathscr{Q}}} = 3.50 * \frac{14}{2}$

$= 24.50^{K\text{-}ft}$

$P_{a_{\mathscr{Q}}} = 19.40 * 250 * 0.283 * 1.47$

$= 2.02^K$

$M_{P_{a\mathscr{Q}}} = 2.02 * \frac{19.40}{2}$

$= 19.57^{K\text{-}ft}$

$P_a = \frac{(19.40)^2}{2} * 138 * 0.283 * 1.47$

$= 9.08^K$

$M_{P_a} = 9.08 * \frac{19.40}{3}$

$= 58.75^{K\text{-}ft}$

$F_R = 37.48 * \tan 30$

$= 21.64^K$

$FS_{SL} = \frac{21.64}{2.02 + 9.08} = 1.95 > 1.50$ ✓ $\quad FS_{OT} = \frac{262.36 + 24.50}{19.57 + 58.75} = 3.66 > 2.00$ ✓

$e = \frac{14}{2} - \frac{(262.36 + 24.50) - (19.57 + 58.75)}{37.48 + 3.50} = 1.91 \leq \frac{B}{6} = 2.33$ ✓

$\sigma_{vb} = \frac{37.48 + 3.50}{14 - 2(1.91)} = 4.03^{KSF}$

$\frac{\sigma_{vb}}{H_W} = \frac{4.03}{19.40} = 207.55$ psf

DATE 7-26-88	RETAINED EARTH™ WALL	**VSL Corporation** Dallas — (214) 647-0200 Denver — (303) 779-1155 Houston — (713) 444-9045	PROJ. NO. 278-PB348MT
DES. BY MT	INTERNAL STABILITY		
DWN. BY MT	MIDDLECREEK DAM DOWNSTREAM WALL COLUMN 6		
CKD. BY			SHT. 2 OF

	DRIVING FORCE					PULLOUT						MESH				
LAYER	z_a	K	$\frac{\sigma_{vb}}{H_{eff}}$	A_t	FH	z	A_c	N	γ	PR	FS	TYPE	b*d	A_b	f_m	COMMENT
1	1.58	0.426	207.55	13.64	1.91	2.525	36.84	9	62.6	3.27	1.71	5W11	0.0624	0.55	3.47	POLLOUT GOVERNS
2	3.775	0.411		5.41	1.87	3.775	35.28			3.51	1.88	4W11	0.0468	0.44	4.25	BMIN GOVERNS
3	5.025	0.401			2.26	5.025	33.72			4.46	1.98				5.14	
4	6.275	0.391			2.75	6.275	32.16			5.32	1.93				6.26	
5	7.525	0.382			3.23	7.525	30.59			6.07	1.88				7.34	
6	8.775	0.372			3.66	8.775	29.03	↓		6.71	1.83				8.33	
7	10.025	0.362			4.67	10.025	27.47	*		7.26	1.78				9.26	
8	11.275	0.352			4.46	11.275	25.91			7.70	1.73				10.13	
9	12.525	0.342			4.81	12.525	24.34			8.04	1.67				10.93	
10	13.775	0.332			5.14	13.775	22.78			8.27	1.61				11.67	
11	15.025	0.322			5.43	15.025	21.22			8.40	1.55				12.35	↓
12	16.275	0.312			5.70	16.275	19.65			8.43	1.48	↓	↓	↓	12.95	FS_{PULL} = OK (TRANSIENT)
13	17.525	0.302			6.05	17.525	18.10			11.14	1.84	5W11	0.0624	0.55	11.00	
14	18.775	0.293	↓	↓	6.18	18.775	16.53	↓	↓	10.91	1.76	5W11	0.0624	0.55	11.24	POLLOUT GOVERNS

* IGNORE BI-LINEAR FAILURE PLAIN - USE CONSTANT VERTICAL FAILURE SURFACE @ 0.3H. (DUE TO 'POOR' ANCHORAGE OF IMPERMIABLE FILL)

DATE 7-26-88

DES BY JT

DWN BY JT

CKD BY

RETAINED EARTH™ WALL

INTERNAL STABILITY

MIDDLE CREEK DAM
DOWNSTREAM WALL
COLUMN 6

VSL Corporation

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Denver — (303) 779-1155
Houston — (713) 444-9045

PROJ. NO.

SH. 3 OF

$H_W = H_{MAX.} = 14.40$

$W_V = 14.40 * 12 * 138$

$= 23.85^{K}$

$W_g = 12 * 250$

$= 3.00^{K}$

$P_{ag} = 14.40 * 250 * 0.283 * 1.47$

$= 1.50^{K}$

$P_a = \frac{(14.40)^2}{2} * 138 * 0.283 * 1.47$

$= 5.66^{K}$

$B = 12'$

$M_{WV} = 23.85 * \frac{12}{2}$

$= 143.08^{K \cdot ft}$

$M_{W_g} = 3.00 * \frac{12}{2}$

$= 18.00^{K-ft}$

$M_{P_{ag}} = 1.50 * \frac{14.40}{2}$

$= 10.78^{K \cdot ft}$

$M_{Pa} = 5.66 * \frac{14.40}{3}$

$= 27.16^{K \cdot ft.}$

$F_R = 23.85 * \tan 30$

$= 13.77^{K}$

$FS_{SL} = \frac{13.77}{1.50 + 5.66} = 1.92 > 1.50$ ✓

$FS_{OT} = \frac{143.08}{10.78 + 27.16} = 3.77 > 2.00$ ✓

$e = \frac{12}{2} - \frac{(143.08 + 18.00) - (10.78 + 27.16)}{23.85 + 3.00} = 1.41 \leq \frac{B}{6} = 2.00$ ✓

$\sigma_{vb} = \frac{23.85 + 3.00}{12 - 2(1.41)} = 2.92^{ksf}$

$\frac{\sigma_{vb}}{H_W} = \frac{2.92}{14.40} = 203.11$ psf

DATE
7-26-88

DES. BY

DWN. BY

CKD. BY

RETAINED EARTH™ WALL
EXTERNAL STABILITY

MIDDLE CREEK DAM
DOWNSTREAM WALL
SECTION 1

VSL Corporation

Dallas — (214) 647-0200
Denver — (303) 779-1155
Houston — (713) 444-9045

PROJ. NO.
278-RE3481T

SHT 4 OF__

	DRIVING FORCE					PULLOUT						MESH				
LAYER	Z_a	K	$\frac{\sigma_{vb}}{H_{eff}}$	A_t	FH	Z	A_c	N	γ	PR	FS	TYPE	b*d	A_b	f_{mi}	COMMENT
1	1.53	0.428	205.11	13.61	1.87	2.525	36.84	8	62.6	2.90	1.55	5W11	0.0625	0.55	5.40	PULLOUT GOVERNS
2	3.775	0.411	↓	5.41	1.83	3.775	35.28	↓	↓	3.12	1.70	4W11	0.0463	0.44	4.16	[illegible] GOVERNS
3	5.025	0.401	↓	↓	2.21	5.025	33.72	↓	↓	3.97	1.80	↓	↓	↓	5.03	↓
4	6.275	0.391	↓	↓	2.69	6.275	32.16	↓	↓	4.75	1.76	↓	↓	↓	6.12	↓
5	7.525	0.382	↓	↓	3.16	7.525	30.59	*	↓	5.39	1.71	↓	↓	↓	7.18	↓
6	8.775	0.372	↓	↓	3.58	8.775	29.03	↓	↓	5.97	1.67	↓	↓	↓	8.14	↓
7	10.025	0.362	↓	↓	3.98	10.025	27.47	↓	↓	6.45	1.62	↓	↓	↓	9.05	↓
8	11.275	0.352	↓	↓	4.36	11.275	25.91	↓	↓	6.94	1.57	↓	↓	↓	9.92	↓
9	12.525	0.342	↓	↓	4.71	12.525	24.34	↓	↓	7.14	1.52	↓	↓	↓	10.70	↓
10	13.775	0.332	↓	↓	5.03	13.775	22.78	↓	↓	7.73	1.46	↓	↓	↓	11.43	FS_{PULL} = OK (TRANSIENT)

* IGNORE BI-LINEAR FAILURE PLANE - USE CONSTANT VERTICAL FAILURE SURFACE @ 0.3H [illegible]

DATE 7-26-88

DES BY JT

DWN BY JT

CKD BY

RETAINED EARTH™ WALL
INTERNAL STABILITY

MIDDLE CREEK DAM
DOWNSTREAM WALL
COLUMN 2

VSL Corporation

Dallas — (214) 647-0200
Denver — (303) 779-1155
Houston — (713) 444-9045

PROJ. NO. 278-PB3487T

SH. 5 OF

$H_W = H_{MAX} = 9.40$

$B = 10$

$W_M = 9.40 * 10 * 138$

$= 12.97^{K.}$

$M_{WM} = 12.97 * \frac{10}{2}$

$= 64.86^{K\text{-}ft}$

$W_g = 10 * 250$

$= 2.50^{K}$

$M_{W_g} = 2.50 * \frac{10}{2}$

$= 12.50^{K\text{-}ft}$

$P_{ag} = 9.40 * 250 * 0.283 * 1.47$

$= 0.98^{K}$

$M_{P_{ag}} = 0.98 * \frac{9.40}{2}$

$= 4.59^{K\text{-}ft}$

$P_a = \frac{(9.40)^2}{2} * 138 * 0.283 * 1.47$

$= 2.54^{K}$

$M_{P_a} = 2.54 * \frac{9.40}{3}$

$= 7.95^{K\text{-}ft.}$

$F_R = 12.97 * \tan 30$

$= 7.49^{K}$

$FS_{SL} = \frac{7.49}{0.98 + 2.54} = 2.13 > 1.50$ ✓

$FS_{OT} = \frac{64.86}{4.59 + 7.95} = 5.17 > 2.00$ ✓

$e = \frac{10}{2} - \frac{(64.86 + 12.50) - (4.59 + 7.95)}{12.97 + 2.50} = 0.81 < \frac{B}{6} = 1.67$ ✓

$\sigma_{vb} = \frac{12.97 + 2.50}{10 - 2(0.81)} = 1.85^{ksf}$

$\frac{\sigma_{vb}}{H_W} = 196.39$ Psf

DATE			PROJ. NO.
7-26-88	RETAINED EARTH™ WALL	**VSL Corporation**	278-FB348HT
DES. BY KT	EXTERNAL STABILITY	Dallas — (214) 647-0200 Denver — (303) 779-1155 Houston — (713) 444-9045	
DWN. BY KT	MIDDLE CREEK DAM DOWNSTREAM WALL [illegible] ?		
CKD. BY			SHT 6 OF

	DRIVING FORCE					PULLOUT						MESH				
LAYER	z_a	K	$\frac{\sigma_{vb}}{H_{eff}}$	A_t	FH	z	A_c	N	γ	PR	FS	TYPE	b*d	A_b	f_m	COMMENT
1	1.58	0.418	196.39	13.64	1.81	0.525	36.84	8	62.6	2.90	1.60	5W11	0.0624	0.55	3.29	PULLOUT GOVERNS
2	3.775	0.411		3.41	1.77	[illegible]	35.28	↓		3.12	1.76	4W11	0.0468	0.44	4.02	BMIN GOVERNS
3	5.035	0.401			2.14	[illegible]	33.72	*		3.97	1.85				4.86	
4	[illegible]	[illegible]			2.60	[illegible]	32.16			4.73	1.82				5.91	
5	[illegible]	0.382			3.06	7.525	30.59			5.39	1.76				6.95	
6	[illegible]	[illegible]	↓	↓	3.46	[illegible]	29.03	↓	↓	5.97	1.72	↓	↓	↓	7.86	↓

* IGNORE BI-LINEAR FAILURE PLAIN - USE CONSTANT VERTICAL FAILURE SURFACE @ 0.3Hw. (DUE TO 'POOR' ANCHORAGE OF IMPERMIABLE FILL)

DATE 7-26-88

DES BY JT

DWN BY JT

CKD. BY

RETAINED EARTH™ WALL

INTERNAL STABILITY

MIDDLE CREEK DAM
DOWNSTREAM WALL
COLUMN 2

VSL Corporation

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Denver — (303) 779-1155
Houston — (713) 444-9045

PROJ. NO. 276-RE2481

SH. 7 OF

APPENDIX F

APPENDIX F-1

UPPER CHUTE BAFFLED APRON

APPENDIX F-1
UPPER CHUTE BAFFLED APRON

```
     GIVEN:
        FLOW AT PMF =  3250 cfs
        DESIGN FLOW =  1625 cfs
        CHUTE WIDTH =    37 ft

                                     Unit q =  43.92 cfs/ft
                                Crit. depth =   3.91 ft


       BAFFLE HEIGHT:(0.8Dc - 0.9Dc)
                    (   3.13   3.52 )             USE H =  3.25 ft


       BAFFLE WIDTH:  (  H   -   1.5H )
                    (   3.25   4.88 )             USE W =  4.67 ft

       EDGE BLOCK WIDTH:   ( H/3   -  2H/3   )
                           (   1.08   2.17 )      USE Wp=  2.17 ft

               Chute width =     7 Baffles

       BAFFLE ROW SPACING:  (2H)
                           (    6.5 )             USE S =  6.50 ft

       MINIMUM WALL HEIGHT: (3H)
                           (   9.75 )             USE h3= 10.00 ft
```

Source: HKM Associates, 1988

APPENDIX F-2

LOWER CHUTE BAFFLED APRON

APPENDIX F-2
LOWER CHUTE BAFFLED APRON

GIVEN:
FLOW AT PMF = 1800 cfs
DESIGN FLOW = 1000 cfs
CHUTE WIDTH = 25 ft

Unit q = 40.00 cfs/ft
Crit. depth = 3.68 ft

BAFFLE HEIGHT: (0.8Dc - 0.9Dc)
(2.94 3.31) USE H = 3 ft

BAFFLE WIDTH: (H - 1.5H)
(3 4.50) USE W = 4.25 ft

EDGE BLOCK WIDTH: (H/3 - 2H/3)
(1.00 2.00) USE Wp= 1.88 ft

Chute width = 5 Baffles

BAFFLE ROW SPACING: (2H)
(6) USE S = 6.00 ft

MINIMUM WALL HEIGHT: (3H)
(9) USE h3= 9.00 ft

Source: HKM Associates, 1988

APPENDIX F-3

STABILITY OF BAFFLED APRON DROP STRUCTURES

APPENDIX F-3

STABILITY OF BAFFLED APRON DROP STRUCTURES

INTRODUCTION

The purpose of this paper is to describe the stability evaluation of the principal spillway. The spillway consists of an open channel over the right abutment area. The spillway control section is a labyrinth weir. Spillway flows pass through two concrete drop structures herein identified as the lower and upper drop structures.

The lower drop structure is a concrete chute, 25 feet wide with 9 foot high sidewalls and 186 feet long. The structure will have a slope of 2:1 (horizontal to vertical, 26.6°). Energy will be dissipated by concrete baffles cast into the floor of the chute. The baffles are arranged in rows 6 feet apart.

The upper baffled structure will be similar to the lower structure with a width of 37 feet, variable wall heights and a length of 60 feet. The concrete baffles are arranged in rows 6.5 feet apart.

APPROACH

The approach to stability consisted of first evaluating the potential for hydrostatic uplift. This was done by drawing a flownet for each structure. Then all the loads or driving forces on the structures were calculated. Resistance to sliding was determined and a factor of safety representing safety against a sliding failure was calculated.

For convenience, these concrete structures were divided into segments of 6 and 6.5 feet long for the lower and upper structure, respectively. A freebody diagram representing the resulting forces on these segments is shown on Figure 1. Stability was calculated by summing the forces around the freebody diagram.

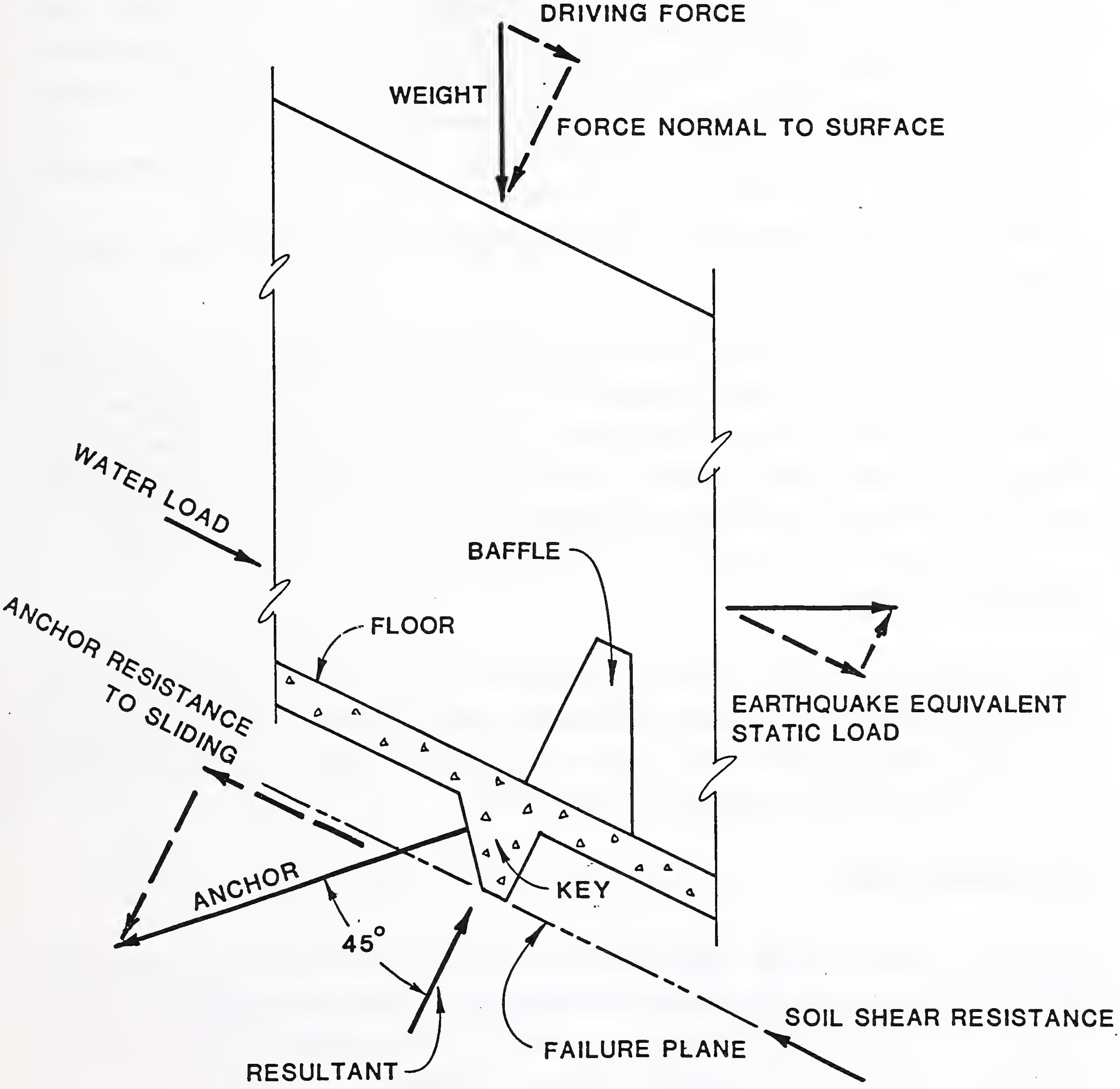
The factors of safety against sliding were calculated and compared with the design standards. Where resistance forces were insufficient, additional resistance was achieved by including soil anchors and a concrete key under the floor slab. The key is also represented in Figure 1. Discussions of the anchor and key designs are presented later.

DESIGN

Forces were calculated to represent the loading conditions. The following three cases were considered:

Dead Load (DL)	static weight of the in-place structure.
DL + PMF	weight of the structure plus the hydraulic loading resulting from water flowing through the structure during the Probable Maximum Flood (PMF).
DL + Earthquake	weight of the structure plus the equivalent static load created by a seismic event.

The loads and resisting forces are further described under the following subheading.


DRIVING FORCE
WEIGHT
FORCE NORMAL TO SURFACE
WATER LOAD
BAFFLE
FLOOR
ANCHOR RESISTANCE TO SLIDING
EARTHQUAKE EQUIVALENT STATIC LOAD
KEY
ANCHOR
45°
SOIL SHEAR RESISTANCE
FAILURE PLANE
RESULTANT

STABILITY OF BAFFLED APRON DROP STRUCTURES

FREE BODY DIAGRAM

FIGURE 1

HKM ASSOCIATES
ENGINEERS · PLANNERS

8M087.136	JUNE 1987

Dead Load

The dead load was determined by calculating the weight of the concrete in the floor, walls and baffles. Additionally, the weight of soils above the portion of the footing which extends 1.5 feet beyond the outside edge of the chute was added to the weight of the concrete. It was assumed that this soil will settle slightly after construction creating negative skin friction on the wall of the chute. The total soil load is assumed to be the weight of the soil block 1.5 feet wide by 8 feet high.

The dead load calculation for determining the driving force during a seismic event consists of subtracting the component of the earthquake load, normal to the slope of the spillway floor, from the dead load normal to the floor, then using this new value to calculate shear strength.

Hydraulic Load

The hydraulic force acting perpendicular to the face of each baffle consists of the velocity head plus the hydrostatic pressure associated with flow at critical depth at the maximum flow, the probable maximum flood (PMF).

Earthquake Load

Seismic loads were evaluated by calculating an equivalent static force which acts horizontally. The equivalent static force was calculated based on methods described in the Uniform Building Code and AASHTO design methods. A coefficient to multiply times the dead load was determined for each method and this value was compared to a value determined in an earlier seismic study done by HKM. A coefficient of 0.22 was used to calculate the horizontal equivalent static force for this project.

Resistance

Primary resistance to sliding is provided by the shear strength of the soil along a plane through the deepest point of the concrete. Additional resistance is provided by the battered anchor. Only the component of the anchor capacity parallel to the surface of the structure was used to calculate sliding resistance.

Some resistance to sliding is also provided by the lower toe of both drop structures. The toes are buried and have flared wing walls. At each structure it was assumed that the resistance to sliding provided by the buried toe will be substituted for two anchors at each structure. The lower two anchors were eliminated. The anchors provide 10k each of sliding resistance, parallel to the floor of the structure. Since the sliding resistance provided by the buried toes is greater than 40 kips at each structure this is a conservative assumption.

Factors of Safety

The factors of safety (FS) used in design are as follows:

FS = 1.50 for DL
FS = 1.15 for DL + PMF
FS = 1.15 for DL + Earthquake (EQ)

Anchor capacities were calculated using a FS = 1.5. The net anchor capacities were applied to calculate the design FS thus compounding the FS.

DESIGN

Anchor Design

The following conditions exist at the baffled apron drop structures.

1. There is no bedrock at either the upper or lower baffled apron drops. Therefore soil anchors will be used to provide additional resistance to sliding.

2. The soil at both sites is predominantly clayey gravel. At the lower structure, silty gravel with sand is identified. Because the clayey gravel has lower strength and because the material is glacial fill, and heterogeneous, the anchors should be designed assuming clayey gravel soils. While the internal angle of friction is similar at both structures, it appears justified to assume no cohesion is available at the lower structure but minor cohesion is available at the upper structure.

3. At the lower baffled structure, ground water may be as high as 6,612 feet which means that the toe of the structure may be saturated at times. Saturated conditions may develop at the contact between the concrete and the soil from minor seepage under the structure. However, the subsoil is not expected to be saturated for the full length of the anchors under the slab.

4. At the upper baffled structure, the foundation and subsoil will likely be saturated throughout.

A 6-inch diameter anchor was selected because of general acceptance and local drilling capabilities. As stated above, the subsoil is primarily a clayey gravel with some cobbles and boulders. Because of the variable nature of the soil, the anchors will probably need to be installed using casing and a downhole hammer (Odec System).

The anchor capacity was calculated using the following parameters.

Anchor capacity = soil shear strength x surface area x length

$\gamma d = 95$ pcf

MC = 15%

$\phi = 34°$

c = 0 at lower and 80 psf for upper structure

FS = 1.5

The internal angle of friction (ϕ) was determined by using a weighted average of all standard penetration resistance values and then selecting ϕ from recognized correlation charts (Department of the Navy, 1982).

No cohesion (c) was assumed for the design of anchors for the lower structure because the logs indicates the soil has less fine-grained material.

A low cohesion value of 80 pounds per square foot is justified for the upper structure for two reasons:

1. The logs indicate a distinct clayey soil matrix with some plasticity.

2. Much of the soil in which the anchors will be placed, will be engineered fill with some fines. Densities in the fill will be controlled.

The anchors are battered 45° which is as much as is practical from a construction standpoint.

The lower structure is designed with a total of 28 soil anchors, 6 inches in diameter and 20 feet long. The anchor capacity is 14.1 kips with a factor of safety of 1.5.

The upper structure is designed with 10 soil anchors, 6 inches in diameter and 25 feet long. The anchor capacity for this saturated condition is 14.1 kips with a factor of safety of 1.5.

Key

Concrete keys are included in the foundation design for both structures. The purpose of the key is to create a plane of resistance to sliding below the actual floor of the spillway. For the lower structure, the key is 18 inches deep while the depth is 12 inches for the upper structure. The anchors ensure that the plane of resistance is at the deepest point of the key.

An economic analysis was made to evaluate the potential for eliminating the keys by increasing the anchor lengths. It was determined it is less expensive to retain the keys and reduce the anchor length. An optimum combination of anchors and foundation keys was selected for final design.

RESULTS

The resulting factors of safety for the loading conditions analyzed are as follows:

$$DL = \frac{\text{soil shear resistance + anchor resistance}}{\text{driving forces}}$$

$$\text{DL+PMF} = \frac{\text{shear resist. (wt. of water included) + anchor resist. (only resistance parallel to surface)}}{\text{driving forces (driving component of wt. + hydraulic force)}}$$

$$\text{DL+EQ} = \frac{\text{shear resist. (wt. reduced by seismic) + anchor resist.}}{\text{driving forces (driving component of weight + horizontal component of seismic force)}}$$

Lower Structure

Design Condition	Calculation		Factor of Safety
DL	$\frac{40.0 + 10.0}{27.3}$	=	1.83
DL + PMF	$\frac{68.6 + 10.0}{27.3 + 17.4}$	=	1.76
DL + EQ	$\frac{36.3 + 10.0}{39.3}$	=	1.18

Upper Structure

Design Condition	Calculation		Factor of Safety
DL	$\frac{54.9 + 10.0}{36.1}$	=	1.80
DL + PMF	$\frac{84.0 + 10.0}{36.0 + 29.5}$	=	1.44
DL + EQ	$\frac{50.7 + 10.0}{48.4}$	=	1.26

APPENDIX F-4

HEC-2 PRINTOUT - PRINCIPAL SPILLWAY

APPENDIX F-4

SECTION #	PRINCIPAL SPILLWAY STA.
1	23+20
2	23+05
3	22+95
4	22+80
5	22+60
6	22+20
7	21+35
8	20+95
9	20+75
10	20+25
11	19+85
12	19+10
13	18+10
14	17+10
15	16+25
16	15+90
17	14+70
18	13+55
19	13+15
20	12+85

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*******************************************************            *****************************************
*  WATER SURFACE PROFILES                             *            *  U.S. ARMY CORPS OF ENGINEERS         *
*  VERSION OF NOVEMBER 1976                           *            *  THE HYDROLOGIC ENGINEERING CENTER    *
*  UPDATED MAY 1984                                   *            *  609 SECOND STREET, SUITE D           *
*  IBM-PC-XT VERSION                                  *            *  DAVIS, CALIFORNIA 95616              *
*  RUN DATE  04/14/88  TIME  16:21:11                 *            *  (916) 440-2105 (FTS) 448-2105        *
*******************************************************            *****************************************


                                                  X     X  XXXXXXX    XXXXX                XXXXX
                                                  X     X  X         X     X              X     X
                                                  X     X  X         X                          X
                                                  XXXXXXX  XXXX      X          XXXXX      XXXXX
                                                  X     X  X         X                    X
                                                  X     X  X         X     X              X
                                                  X     X  XXXXXXX    XXXXX               XXXXXXX
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                                                                THIS RUN EXECUTED 04/14/88   16:21:22
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION APRIL 1985
**************************************************


SPLIT FLOW BEING PERFORMED


SF     FILE IHEC2PS1 - SPLIT FLOW OVER MEADOW DIKE


TW      TOP OF DIKE AT 6692.0
WS      2      9.0     15.0      -1       2.8
WC      0  6692.0       480  6692.3
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T1          MIDDLE CREEK RESERVOIR - PRINCIPAL SPILLWAY
T2          MEADOW DIKE ANALYSIS - 25 FT LOWER CHUTE, CREST = 6683.3
T3          MAX SPILLWAY DISCHARGE = 3250 CFS

J1   ICHECK      INQ        NINV       IDIR       STRT       METRIC     HVINS      Q          WSEL       FQ

          0.         2.         0.         0.  -1.000000        .00        .0         0.   6687.000       .000

J2   NPROF       IPLOT      PRFVS      XSECV      XSECH      FN         ALLDC      IBW        CHNIM      ITRACE

        1.000       .000     -1.000       .000       .000       .000       .000       .000       .000       .000


QT       7.000    100.000    500.000    750.000   1000.000   1500.000   2000.000   3250.000       .000       .000
NC        .015       .015       .015       .600       .800       .000       .000       .000       .000       .000
X1       1.000      4.000       .000     25.000       .000       .000       .000       .000       .000       .000
GR    6696.000       .000   6683.300       .000   6683.300     25.000   6696.000     25.000       .000       .000

X1       2.000      4.000       .000     25.000     15.000     15.000     15.000       .000       .000       .000
GR    6696.000       .000   6682.300       .000   6682.300     25.000   6696.000     25.000       .000       .000

NC        .100       .100       .030       .000       .000       .000       .000       .000       .000       .000
X1       3.000      5.000      8.000    105.000     10.000     10.000     10.000       .000       .000       .000
GR    6697.000       .000   6696.500      8.000   6682.100     40.000   6682.100     70.000   6697.000    105.000

NC        .100       .100       .040       .300       .100       .000       .000       .000       .000       .000
X1       4.000      5.000     10.000    110.000     15.000     15.000     15.000       .000       .000       .000
GR    6698.000       .000   6696.000     10.000   6682.300     37.000   6682.300     77.000   6698.000    110.000

X1       5.000      5.000     50.000    144.000     20.000     20.000     20.000       .000       .000       .000
GR    6696.000       .000   6690.000     50.000   6682.600     63.000   6682.600    103.000   6700.000    144.000

X1       6.000      8.000    152.000    240.000     40.000     40.000     40.000       .000       .000       .000
GR    6696.000       .000   6691.000     50.000   6690.000     88.000   6688.000    112.000   6688.000    152.000
GR    6683.200    159.000   6683.200    199.000   6701.500    240.000       .000       .000       .000       .000

X1       7.000      8.000    178.000    253.000     85.000     85.000     85.000       .000       .000       .000
GR    6695.000       .000   6690.000     35.000   6688.000     90.000   6688.000    130.000   6691.000    178.000
GR    6684.400    190.000   6684.400    230.000   6694.500    253.000       .000       .000       .000       .000

X1       8.000      5.000     33.000    116.000     40.000     40.000     40.000       .000       .000       .000
GR    6694.000       .000   6694.000     33.000   6684.900     55.000   6684.900     95.000   6694.000    116.000

X1       9.000      8.000     56.000    125.000     20.000     20.000     20.000       .000       .000       .000
GR    6694.000       .000   6694.000     51.000   6693.000     56.000   6685.200     75.000   6685.200    115.000
GR    6689.500    125.000   6689.500    140.000   6690.000    142.000       .000       .000       .000       .000

X1      10.000      6.000     53.000    134.000     40.000     55.000     50.000       .000       .000       .000
GR    6695.000       .000   6694.000     22.000   6690.500     53.000   6685.900     64.000   6685.900    124.000
GR    6690.000    134.000       .000       .000       .000       .000       .000       .000       .000       .000
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X1     11.000      6.000     55.000    125.000     25.000     55.000     40.000       .000       .000       .000
GR   6695.000       .000   6694.000     25.000   6690.000     55.000   6685.900     75.000   6685.900    115.000
GR   6690.000    125.000       .000       .000       .000       .000       .000       .000       .000       .000

X1     12.000      6.000     40.000    110.000     60.000     75.000     75.000       .000       .000       .000
GR   6696.000       .000   6695.000     19.000   6690.000     40.000   6685.900     60.000   6685.900    100.000
GR   6690.000    110.000       .000       .000       .000       .000       .000       .000       .000       .000

X1     13.000      6.000     35.000    155.000    100.000    100.000    100.000       .000       .000       .000
GR   6697.000       .000   6690.000     35.000   6687.000     53.000   6686.000     70.000   6685.900    145.000
GR   6690.000    155.000       .000       .000       .000       .000       .000       .000       .000       .000

X1     14.000      6.000     37.000    165.000     70.000    100.000    100.000       .000       .000       .000
GR   6699.000       .000   6690.000     37.000   6687.000     52.000   6686.000    100.000   6686.500    157.000
GR   6690.000    165.000       .000       .000       .000       .000       .000       .000       .000       .000

X1     15.000      5.000     55.000    190.000     60.000     65.000     65.000       .000       .000       .000
GR   6699.000       .000   6690.000     55.000   6687.000     85.000   6688.000    160.000   6690.000    190.000

X1     16.000      7.000     25.000    104.000     15.000    100.000     35.000       .000       .000       .000
GR   6697.000       .000   6693.000     25.000   6687.000     36.000   6687.000     60.000   6687.000     98.000
GR   6690.000    104.000   6700.000    135.000       .000       .000       .000       .000       .000       .000

X1     17.000      6.000       .000     80.000    120.000    120.000    120.000       .000       .000       .000
GR   6693.000       .000   6687.000     12.000   6687.000     32.000   6687.000     62.000   6694.000     80.000
GR   6700.000    128.000       .000       .000       .000       .000       .000       .000       .000       .000

X1     18.000      5.000       .000    128.000    115.000    115.000    115.000       .000       .000       .000
GR   6712.000     10.000   6687.000     46.000   6687.000     86.000   6704.000    128.000   6710.000    153.000

X1     19.000      5.000       .000    129.000     40.000     40.000     40.000       .000       .000       .000
GR   6714.000       .000   6687.000     54.000   6687.000     94.000   6704.000    129.000   6710.000    148.000

X1     20.000      7.000     20.000     90.000     30.000     30.000     30.000       .000       .000       .000
GR   6705.000       .000   6695.000     20.000   6688.000     34.000   6687.000     40.000   6688.000     67.000
GR   6695.000     90.000   6705.000    108.000       .000       .000       .000       .000       .000       .000
EJ       .000       .000       .000       .000       .000       .000       .000       .000       .000       .000
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*PROF 1


CCHV=      .600 CEHV=      .800
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED
      1.00        .79  6684.09    6684.09    6687.00    6684.49        .40        .00        .00   6696.00
      100.         0.     100.         0.         0.        20.         0.         0.         0.    6696.00
       .00        .00     5.07        .00       .015       .015       .015       .000    6683.30       .00
   .003889         0.       0.         0.          0         16          0        .00      25.00     25.00


*SECNO 2.000
      2.00       2.36  6684.66        .00        .00    6684.71        .04        .01        .21   6696.00
      100.         0.     100.         0.         0.        59.         0.         0.         0.    6696.00
       .00        .00     1.70        .00       .015       .015       .015       .000    6682.30       .00
   .000118        15.      15.        15.          4          0          0        .00      25.00     25.00


*SECNO 3.000
      3.00       2.60  6684.71        .00        .00    6684.72        .02        .00        .02   6696.50
      100.         0.     100.         0.         0.        94.         0.         0.         0.    6697.00
       .01        .00     1.07        .00       .100       .030       .100       .000    6682.10     34.21
   .000164        10.      10.        10.          2          0          0        .00      41.91     76.12


CCHV=      .300 CEHV=      .100
*SECNO 4.000
      4.00       2.41  6684.71        .00        .00    6684.73        .01        .00        .00   6696.00
      100.         0.     100.         0.         0.       108.         0.         0.         0.    6698.00
       .01        .00      .92        .00       .100       .040       .100       .000    6682.30     32.24
   .000225        15.      15.        15.          2          0          0        .00      49.83     82.07


*SECNO 5.000
      5.00       2.12  6684.72        .00        .00    6684.73        .02        .01        .00   6690.00
      100.         0.     100.         0.         0.        94.         0.         0.         0.    6700.00
       .01        .00     1.07        .00       .100       .040       .100       .000    6682.60     59.28
   .000352        20.      20.        20.          2          0          0        .00      48.70    107.99


*SECNO 6.000
      6.00       1.52  6684.72        .00        .00    6684.76        .04        .02        .00   6688.00
      100.         0.     100.         0.         0.        65.         0.         0.         0.    6701.50
       .02        .00     1.53        .00       .100       .040       .100       .000    6683.20    156.78
   .001081        40.      40.        40.          2          0          0        .00      45.64    202.41
   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*SECNO 7.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
      7.00        .57    6684.97    6684.97        .00    6685.25        .28        .26        .02    6691.00
      100.         0.       100.         0.         0.        23.         0.         0.         0.    6694.50
       .03        .00       4.26        .00       .100       .040       .100       .000    6684.40     188.96
   .029007        85.        85.        85.         20         18          0        .00      42.34     231.30


*SECNO 8.000
      8.00        .83    6685.73        .00        .00    6685.85        .13        .55        .05    6694.00
      100.         0.       100.         0.         0.        35.         0.         0.         0.    6694.00
       .03        .00       2.85        .00       .100       .040       .100       .000    6684.90      52.98
   .008059        40.        40.        40.          2          0          0        .00      43.95      96.93


*SECNO 9.000
      9.00        .69    6685.89        .00        .00    6686.07        .19        .22        .01    6693.00
      100.         0.       100.         0.         0.        29.         0.         0.         0.    6689.50
       .03        .00       3.49        .00       .100       .040       .100       .000    6685.20      73.32
   .015400        20.        20.        20.          2          0          0        .00      43.28     116.60


*SECNO 10.000
     10.00        .66    6686.56        .00        .00    6686.65        .10        .55        .03    6690.50
      100.         0.       100.         0.         0.        40.         0.         0.         0.    6690.00
       .04        .00       2.49        .00       .100       .040       .100       .000    6685.90      62.44
   .008275        40.        50.        55.          1          0          0        .00      63.15     125.59


*SECNO 11.000
     11.00        .93    6686.83        .00        .00    6686.92        .10        .27        .00    6690.00
      100.         0.       100.         0.         0.        40.         0.         0.         0.    6690.00
       .04        .00       2.50        .00       .100       .040       .100       .000    6685.90      70.50
   .005595        25.        40.        55.          2          0          0        .00      46.76     117.25


*SECNO 12.000
     12.00       1.23    6687.13        .00        .00    6687.18        .05        .25        .01    6690.00
      100.         0.       100.         0.         0.        54.         0.         0.         0.    6690.00
       .05        .00       1.84        .00       .100       .040       .100       .000    6685.90      54.04
   .002154        60.        75.        75.          2          0          0        .00      48.94     102.98
   SECNO      DEPTH     CWSEL      CRIWS      WSELK      EG        HV        HL        OLOSS    BANK ELEV
   Q          QLOB      QCH        QROB       ALOB       ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME       VLOB      VCH        VROB       XNL        XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE      XLOBL     XLCH       XLOBR      ITRIAL     IDC       ICONT     CORAR     TOPWID      ENDST


*SECNO 13.000
     13.00      1.37   6687.27        .00        .00   6687.28       .01       .08       .01   6690.00
      100.        0.      100.         0.         0.      114.        0.        1.        1.   6690.00
       .09       .00       .88        .00       .100      .040      .100      .000   6685.90     51.41
   .000449      100.      100.       100.          2         0         0       .00     96.92    148.33

*SECNO 14.000
     14.00      1.32   6687.32        .00        .00   6687.34       .02       .06       .00   6690.00
      100.        0.      100.         0.         0.      102.        0.        1.        1.   6690.00
       .11       .00       .98        .00       .100      .040      .100      .000   6686.00     50.39
   .000768       70.      100.       100.          2         0         0       .00    108.49    158.88

*SECNO 15.000
3685 20 TRIALS ATTEMPTED WSEL,CWSEL
3693 PROBABLE MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
     15.00       .81   6687.81    6687.81        .00   6688.01       .20       .15       .02   6690.00
      100.        0.      100.         0.         0.       28.        0.        1.        1.   6690.00
       .12       .00      3.63        .00       .100      .040      .100      .000   6687.00     76.95
   .032136       60.       65.        65.         20        14         0       .00     68.44    145.39

*SECNO 16.000
     16.00      1.15   6688.15        .00        .00   6688.18       .03       .12       .05   6693.00
      100.        0.      100.         0.         0.       74.        0.        1.        1.   6690.00
       .13       .00      1.36        .00       .100      .040      .100      .000   6687.00     33.89
   .001171       15.       35.       100.          3         0         0       .00     66.40    100.30

*SECNO 17.000
     17.00      1.29   6688.29        .00        .00   6688.32       .03       .14       .00   6693.00
      100.        0.      100.         0.         0.       68.        0.        1.        1.   6694.00
       .15       .00      1.47        .00       .100      .040      .100      .000   6687.00      9.42
   .001209      120.      120.       120.          2         0         0       .00     55.89     65.31

*SECNO 18.000
     18.00      1.43   6688.43        .00        .00   6688.47       .04       .15       .00   6762.00
      100.        0.      100.         0.         0.       61.        0.        1.        1.   6704.00
       .17       .00      1.64        .00       .100      .040      .100      .000   6687.00     43.95
   .001348      115.      115.       115.          2         0         0       .00     45.58     89.52
   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*SECNO 19.000
     19.00       1.48  6688.48        .00        .00  6688.52        .04        .05        .00  6714.00
      100.         0.     100.         0.         0.      64.         0.         1.         1.   6704.00
       .18        .00     1.57        .00       .100      .040       .100      .000   6687.00     51.04
   .001178        40.      40.        40.          2         0          0        .00     46.01     97.05

*SECNO 20.000
     20.00       1.45  6688.45        .00        .00  6688.61        .15        .07        .01  6695.00
      100.         0.     100.         0.         0.      32.         0.         2.         1.   6695.00
       .18        .00     3.12        .00       .100      .040       .100      .000   6687.00     33.09
   .008113        30.      30.        30.          2         0          0        .00     35.41     68.50
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TW      TOP OF DIKE AT 6692.0

    ASQ        QCOMP       ERRAC       TASQ         TCQ        TABER       NITER       DSWS        USWS       DSSNO       USSNO
       .00         .00         .00         .00         .00         .00           2  6685.886   6687.805       9.000      15.000
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                                                                                    THIS RUN EXECUTED 04/14/88   16:24:18
************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION APRIL 1985
************************************************

T1        MIDDLE CREEK RESERVOIR - PRINCIPAL SPILLWAY
T2        MEADOW DIKE ANALYSIS - 25 FT LOWER CHUTE, CREST = 6683.3
T3        MAX SPILLWAY DISCHARGE = 3250 CFS

J1  ICHECK     INQ       NINV       IDIR       STRT       METRIC     HVINS      Q          WSEL       FQ

        0.         3.         0.         0.  -1.000000       .00         .0         0.  6687.000       .000

J2  NPROF      IPLOT     PRFVS      XSECV      XSECH      FN         ALLDC      IBW        CHNIM      ITRACE

       2.000      .000    -1.000       .000       .000       .000       .000       .000       .000       .000
  SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS     BANK ELEV
  Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
  TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
  SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

*PROF 2

CCHV=      .600 CEHV=      .800
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED
      1.00       2.31    6685.61    6685.61    6687.00    6686.77       1.16        .00        .00    6696.00
      500.         0.       500.         0.         0.        58.         0.         0.         0.    6696.00
       .00        .00       8.65        .00       .015       .015       .015       .000    6683.30        .00
   .003131         0.         0.         0.          0         13          0        .00      25.00      25.00

*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

      2.00       4.74    6687.04        .00        .00    6687.32        .28        .01        .53    6696.00
      500.         0.       500.         0.         0.       118.         0.         0.         0.    6696.00
       .00        .00       4.23        .00       .015       .015       .015       .000    6682.30        .00
   .000351        15.        15.        15.          6          0          0        .00      25.00      25.00

*SECNO 3.000
      3.00       5.26    6687.36        .00        .00    6687.44        .08        .00        .12    6696.50
      500.         0.       500.         0.         0.       221.         0.         0.         0.    6697.00
       .00        .00       2.26        .00       .100       .030       .100       .000    6682.10      28.30
   .000336        10.        10.        10.          2          0          0        .00      54.06      82.36

CCHV=      .300 CEHV=      .100
*SECNO 4.000
      4.00       5.09    6687.39        .00        .00    6687.45        .06        .01        .01    6696.00
      500.         0.       500.         0.         0.       256.         0.         0.         0.    6698.00
       .00        .00       1.95        .00       .100       .040       .100       .000    6682.30      26.96
   .000424        15.        15.        15.          2          0          0        .00      60.74      87.70

*SECNO 5.000
      5.00       4.79    6687.39        .00        .00    6687.46        .07        .01        .00    6670.00
      500.         0.       500.         0.         0.       239.         0.         0.         0.    6700.00
       .01        .00       2.09        .00       .100       .040       .100       .000    6682.60      54.58
   .000524        20.        20.        20.          2          0          0        .00      59.71     114.29
```

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     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS     BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST


*SECNO 6.000
        6.00       4.19    6687.39        .00        .00    6687.49        .10        .03        .00    6688.00
        500.         0.       500.         0.         0.       200.         0.         0.         0.    6701.50
         .01        .00       2.50        .00       .100       .040       .100       .000    6683.20     152.88
     .000858        40.        40.        40.          2          0          0        .00      55.52     208.40


*SECNO 7.000
        7.00       3.02    6687.42        .00        .00    6687.62        .20        .12        .01    6691.00
        500.         0.       500.         0.         0.       139.         0.         1.         0.    6694.50
         .02        .00       3.59        .00       .100       .040       .100       .000    6684.40     184.51
     .002616        85.        85.        85.          3          0          0        .00      52.36     236.87


*SECNO 8.000
        8.00       2.59    6687.49        .00        .00    6687.76        .27        .13        .01    6694.00
        500.         0.       500.         0.         0.       119.         0.         1.         0.    6694.00
         .02        .00       4.19        .00       .100       .040       .100       .000    6684.90      48.74
     .004329        40.        40.        40.          2          0          0        .00      52.24     100.98


*SECNO 9.000
        9.00       2.32    6687.52        .00        .00    6687.87        .35        .10        .01    6693.00
        500.         0.       500.         0.         0.       106.         0.         1.         0.    6689.50
         .0[illegible]        .00       4.72        .00       .100       .040       .100       .000    6685.20      69.33
     .006240        20.        20.        20.          2          0          0        .00      51.08     120.41


*SECNO 10.000
       10.00       2.05    6687.95        .00        .00    6688.17        .22        .26        .04    6690.50
        500.         0.       500.         0.         0.       133.         0.         1.         0.    6690.00
         .03        .00       3.76        .00       .100       .040       .100       .000    6685.90      59.10
     .004399        40.        50.        55.          2          0          0        .00      69.90     129.00


*SECNO 11.000
       11.00       2.14    6688.04        .00        .00    6688.41        .37        .23        .02    6690.00
        500.         0.       500.         0.         0.       102.         0.         1.         0.    6690.00
         .03        .00       4.88        .00       .100       .040       .100       .000    6685.90      64.55
     .007771        25.        40.        55.          2          0          0        .00      55.67     120.22
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   SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


*SECNO 12.000
      12.00      2.71   6688.61       .00       .00   6688.83       .21       .37       .05   6690.00
       500.        0.      500.        0.        0.      136.        0.        1.        1.    6690.00
        .03       .00      3.69       .00      .100      .040      .100      .000   6685.90     46.76
    .003375       60.       75.       75.         3         0         0       .00     59.86    106.62


*SECNO 13.000
      13.00      3.05   6688.95       .00       .00   6689.00       .05       .12       .05   6690.00
       500.        0.      500.        0.        0.      289.        0.        2.        1.    6690.00
        .05       .00      1.73       .00      .100      .040      .100      .000   6685.90     41.31
    .000610      100.      100.      100.         2         0         0       .00    111.13    152.44


*SECNO 14.000
      14.00      3.01   6689.01       .00       .00   6689.06       .04       .06       .00   6690.00
       500.        0.      500.        0.        0.      296.        0.        3.        1.    6690.00
        .07       .00      1.69       .00      .100      .040      .100      .000   6686.00     41.93
    .000634       70.      100.      100.         2         0         0       .00    120.81    162.75


*SECNO 15.000
      15.00      1.97   6688.97       .00       .00   6689.17       .21       .10       .02   6690.00
       500.        0.      500.        0.        0.      137.        0.        3.        1.    6690.00
        .07       .00      3.66       .00      .100      .040      .100      .000   6687.00     65.30
    .007196       60.       65.       65.         3         0         0       .00    109.26    174.55


*SECNO 16.000
      16.00      2.16   6689.16       .00       .00   6689.35       .19       .17       .00   6693.00
       500.        0.      500.        0.        0.      142.        0.        3.        1.    6690.00
        .07       .00      3.51       .00      .100      .040      .100      .000   6687.00     32.05
    .003558       15.       35.      100.         2         0         0       .00     70.25    102.30


*SECNO 17.000
      17.00      2.55   6689.55       .00       .00   6689.74       .19       .39       .00   6693.00
       500.        0.      500.        0.        0.      142.        0.        3.        1.    6694.00
        .08       .00      3.51       .00      .100      .040      .100      .000   6687.00      6.90
    .003000      120.      120.      120.         2         0         0       .00     61.65     68.56
   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*SECNO 18.000
     18.00       2.87   6689.87        .00        .00   6690.10        .23        .35        .00   6762.00
      500.         0.      500.         0.         0.      131.         0.         4.         2.    6704.00
       .09        .00      3.81        .00       .100      .040       .100       .000    6687.00     41.86
   .003129       115.      115.       115.          2         0          0        .00      51.24     93.10


*SECNO 19.000
     19.00       3.02   6690.02        .00        .00   6690.22        .20        .11        .01   6714.00
      500.         0.      500.         0.         0.      139.         0.         4.         2.    6704.00
       .05        .00      3.59        .00       .100      .040       .100       .000    6687.00     47.96
   .002617        40.       40.        40.          2         0          0        .00      52.26    100.22


*SECNO 20.000
     20.00       2.88   6689.88        .00        .00   6690.38        .50        .13        .03   6695.00
      500.         0.      500.         0.         0.       88.         0.         4.         2.    6695.00
       .10        .00      5.68        .00       .100      .040       .100       .000    6687.00     30.23
   .009200        30.       30.        30.          2         0          0        .00      42.96     73.19
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TW     TOP OF DIKE AT 6692.0

   ASQ       QCOMP      ERRAC      TASQ        TCQ        TABER      NITER      DSWS       USWS      DSSNO      USSNO
      .00        .00        .00        .00        .00        .00          2  6687.523  6688.965      9.000     15.000
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                                                                                    THIS RUN EXECUTED 04/14/88    16:26:05
*********************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION APRIL 1985
*********************************************


T1         MIDDLE CREEK RESERVOIR - PRINCIPAL SPILLWAY
T2         MEADOW DIKE ANALYSIS - 25 FT LOWER CHUTE, CREST = 6683.3
T3         MAX SPILLWAY DISCHARGE = 3250 CFS

J1  ICHECK     INQ        NINV       IDIR       STRT       METRIC    HVINS      Q          WSEL       FQ

       0.         4.         0.         0. -1.000000        .00        .0         0.  6687.000       .000

J2  NPROF      IPLOT      PRFVS      XSECV      XSECH      FN        ALLDC      IBW        CHNIM      ITRACE

     3.000       .000    -1.000       .000       .000       .000       .000       .000       .000       .000
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

*PROF 3

CCHV=      .600 CEHV=      .800
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED
      1.00      3.03  6686.33  6686.33  6687.00  6687.85      1.53       .00       .00  6696.00
      750         0.      750.       0.       0.       76.        0.        0.        0.   6696.00
       .04       .00      9.91       .00     .015      .015      .015      .000   6683.30       .00
   .003054        0.        0.        0.        0        14         0       .00     25.00     25.00

*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

      2.00      5.82  6688.12       .00       .00  6688.53       .41       .01       .67  6696.00
      750.        0.      750.       0.       0.      146.        0.        0.        0.   6696.00
       .00       .00      5.15       .00     .015      .015      .015      .000   6682.30       .00
   .000430       15.       15.       15.        7         0         0       .00     25.00     25.00

*SECNO 3.000
      3.00      6.52  6688.62       .00       .00  6688.72       .10       .00       .19  6696.50
      750.        0.      750.       0.       0.      293.        0.        0.        0.   6697.00
       .00       .00      2.56       .00     .100      .030      .100      .000   6682.10     25.49
   .000340       10.       10.       10.        2         0         0       .00     59.84     85.34

CCHV=      .300 CEHV=      .100
*SECNO 4.000
      4.00      6.36  6688.66       .00       .00  6688.74       .08       .01       .01  6696.00
      750.        0.      750.       0.       0.      337.        0.        0.        0.   6698.00
       .00       .00      2.23       .00     .100      .040      .100      .000   6682.30     24.47
   .000433       15.       15.       15.        2         0         0       .00     65.90     90.37

*SECNO 5.000
      5.00      6.06  6688.66       .00       .00  6688.75       .09       .01       .00  6670.00
      750.        0.      750.       0.       0.      318.        0.        0.        0.   6700.00
       .01       .00      2.36       .00     .100      .040      .100      .000   6682.60     52.35
   .000513       20.       20.       20.        2         0         0       .00     64.93    117.26
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  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 6.000
     6.00      5.46   6688.66       .00       .00   6688.77       .11       .02       .00   6688.00
     750.        9.      741.        0.       29.      273.        0.        1.        0.   6701.50
      .01       .30      2.71       .00      .100      .040      .100      .000   6683.20    104.05
  .000735       40.       40.       40.         2         0         0       .00    107.19    211.24

*SECNO 7.000

3265 DIVIDED FLOW

     7.00      4.29   6688.69       .00       .00   6688.87       .19       .09       .01   6691.00
     750.       16.      734.        0.       38.      209.        0.        1.        0.   6694.50
      .02       .43      3.51       .00      .100      .040      .100      .000   6684.40     71.01
  .001667       65.       85.       85.         2         0         0       .00    127.60    239.77

*SECNO 8.000
     8.00      3.81   6688.71       .00       .00   6688.96       .25       .08       .01   6694.00
     750.        0.      750.        0.        0.      187.        0.        1.        0.   6694.00
      .02       .00      4.01       .00      .100      .040      .100      .000   6684.90     45.78
  .002535       40.       40.       40.         2         0         0       .00     58.03    103.80

*SECNO 9.000
     9.00      3.52   6688.72       .00       .00   6689.02       .30       .06       .01   6693.00
     750.        0.      750.        0.        0.      171.        0.        1.        0.   6689.50
      .02       .00      4.40       .00      .100      .040      .100      .000   6685.20     66.41
  .003341       20.       20.       20.         2         0         0       .00     56.78    123.20

*SECNO 10.000
    10.00      3.09   6688.99       .00       .00   6689.19       .20       .14       .03   6690.50
     750.        0.      750.        0.        0.      209.        0.        2.        1.   6690.00
      .03       .00      3.59       .00      .100      .040      .100      .000   6685.90     56.59
  .002420       40.       50.       55.         2         0         0       .00     74.97    131.56

*SECNO 11.000
    11.00      3.09   6688.99       .00       .00   6689.34       .35       .13       .01   6690.00
     750.        0.      750.        0.        0.      159.        0.        2.        1.   6690.00
      .03       .00      4.72       .00      .100      .040      .100      .000   6685.90     57.91
  .004761       25.       40.       55.         0         0         0       .00     62.64    122.55
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


*SECNO 12.000
     12.00      3.50   6689.40       .00       .00   6689.65       .25       .28       .03   6690.00
      750.        0.      750.        0.        0.      185.        0.        2.        1.    6690.00
       .02       .00      4.05       .00      .100      .040      .100      .000   6685.90     42.90
   .003048       60.       75.       75.         2         0         0       .00     65.64    108.55


*SECNO 13.000
     13.00      3.86   6689.76       .00       .00   6689.82       .06       .11       .06   6690.00
      750.        0.      750.        0.        0.      383.        0.        3.        1.    6690.00
       .05       .00      1.96       .00      .100      .040      .100      .000   6685.90     36.42
   .000537      100.      100.      100.         2         0         0       .00    118.00    154.42


*SECNO 14.000
     14.00      3.83   6689.83       .00       .00   6689.88       .06       .06       .00   6690.00
      750.        0.      750.        0.        0.      396.        0.        4.        1.    6690.00
       .06       .00      1.89       .00      .100      .040      .100      .000   6686.00     37.87
   .000575       70.      100.      100.         2         0         0       .00    126.73    164.60


*SECNO 15.000
     15.00      2.81   6689.81       .00       .00   6689.97       .15       .07       .01   6690.00
      750.        0.      750.        0.        0.      237.        0.        4.        1.    6690.00
       .07       .00      3.16       .00      .100      .040      .100      .000   6687.00     56.89
   .003254       60.       65.       65.         3         0         0       .00    130.28    187.17


*SECNO 16.000
     16.00      2.85   6689.85       .00       .00   6690.08       .24       .11       .01   6693.00
      750.        0.      750.        0.        0.      172.        0.        4.        2.    6690.00
       .07       .00      3.90       .00      .100      .040      .100      .000   6687.00     30.78
   .003110       15.       35.      100.         2         0         0       .00     72.92    103.70


*SECNO 17.000
     17.00      3.20   6690.20       .00       .00   6690.46       .26       .30       .00   6693.00
      750.        0.      750.        0.        0.      184.        0.        5.        2.    6694.00
       .08       .00      4.09       .00      .100      .040      .100      .000   6687.00      5.59
   .003091      120.      120.      120.         2         0         0       .00     64.64     70.24
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    SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
    Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
    TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
    SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST


*SECNO 18.000
     18.00       3.52   6690.52        .00        .00   6690.84        .32        .38        .01   6762.00
      750.         0.       750.         0.         0.       165.         0.         5.         2.   6704.00
       .06        .00       4.54        .00       .100       .040       .100       .000    6687.00     40.92
   .003487       115.       115.       115.          2          0          0        .00      53.79     94.71


*SECNO 19.000
     19.00       3.70   6690.70        .00        .00   6690.98        .28        .13        .01   6714.00
      750.         0.       750.         0.         0.       176.         0.         5.         2.   6704.00
       .05        .00       4.27        .00       .100       .040       .100       .000    6687.00     46.60
   .002923        40.        40.        40.          2          0          0        .00      55.01    101.62


*SECNO 20.000
     20.00       3.51   6690.51        .00        .00   6691.16        .64        .14        .04   6695.00
      750.         0.       750.         0.         0.       116.         0.         6.         2.   6695.00
       .09        .00       6.44        .00       .100       .040       .100       .000    6687.00     28.96
   .009076        30.        30.        30.          2          0          0        .00      46.31     75.28
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TW      TOP OF DIKE AT 6692.0

    ASQ       QCOMP       ERRAC       TASQ         TCQ         TABER       NITER       DSWS        USWS       DSSNO       USSNO
      .00         .00         .00         .00         .00         .00           2  6688.722  6689.811       9.000      15.000
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                                                                                           THIS RUN EXECUTED 04/14/88    16:27:52
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION APRIL 1985
**************************************************

T1        MIDDLE CREEK RESERVOIR - PRINCIPAL SPILLWAY
T2        MEADOW DIKE ANALYSIS - 25 FT LOWER CHUTE, CREST = 6683.3
T3        MAX SPILLWAY DISCHARGE = 3250 CFS

J1  ICHECK     INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

        0.        5.        0.        0. -1.000000       .00        .0        0.  6687.000      .000

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

      4.000      .000    -1.000      .000      .000      .000      .000      .000      .000      .000
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

*PROF 4

CCHV=      .600 CEHV=      .800
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED
       1.00       3.65  6686.95    6686.95    6687.00    6688.81       1.86        .00        .00   6696.00
     1000.         0.     1000.         0.         0.        91.         0.         0.         0.   6696.00
        .00        .00    10.95        .00       .015       .015       .015       .000   6683.30        .00
    .000157         0.       0.         0.          0          4          0        .00     25.00      25.00

*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

       2.00       4.70  6689.08        .00        .00    6689.62        .54        .02        .79   6696.00
     1000.         0.     1000.         0.         0.       170.         0.         0.         0.   6696.00
        .03        .00     5.90        .00       .015       .015       .015       .000   6682.30        .00
    .000497        15.      15.        15.          7          0          0        .00     25.00      25.00

*SECNO 3.000
       3.00       7.66  6689.76        .00        .00    6689.88        .12        .00        .25   6696.50
     1000.         0.     1000.         0.         0.       365.         0.         0.         0.   6697.00
        .02        .00     2.74        .00       .100       .030       .100       .000   6682.10      22.95
    .000338        10.      10.        10.          2          0          0        .00     65.07      88.02

CCHV=      .300 CEHV=      .100
*SECNO 4.000
       4.00       7.50  6689.80        .00        .00    6689.89        .09        .01        .01   6696.00
     1000.         0.     1000.         0.         0.       415.         0.         0.         0.   6698.00
        .00        .00     2.41        .00       .100       .040       .100       .000   6682.30      22.31
    .000423        15.      15.        15.          2          0          0        .00     70.56      92.77

*SECNO 5.000
       5.00       7.21  6689.81        .00        .00    6689.90        .10        .01        .00   6690.00
     1000.         0.     1000.         0.         0.       395.         0.         0.         0.   6700.00
        .01        .00     2.53        .00       .100       .040       .100       .000   6682.60      30.34
    .000438        20.      20.        20.          2          0          0        .00     67.64 [illegible]
    SECNO       DEPTH     CWSEL       CRIWS       WSELK       EG          HV          HL          OLOSS    BANK ELEV
    Q           QLOB      QCH         QROB        ALOB        ACH         AROB        VOL         TWA    LEFT/RIGHT
    TIME        VLOB      VCH         VROB        XNL         XNCH        XNR         WTN         ELMIN       SSTA
    SLOPE       XLOBL     XLCH        XLOBR       ITRIAL      IDC         ICONT       CORAR       TOPWID      ENDST

*SECNO 6.000
      6.00       6.61   6689.81         .00         .00   6689.93         .11         .02         .00   6688.00
     1000.        46.      954.          0.         92.      343.          0.          1.          0.    6701.50
       .01        .50      2.78         .00        .100      .040        .100        .000    6683.20     90.28
   .000607        40.       40.         40.           2         0           0         .00     123.53     213.81


*SECNO 7.000

3265 DIVIDED FLOW

      7.00       5.45   6689.85         .00         .00   6690.00         .15         .07         .00   6691.00
     1000.        90.      910.          0.        149.      279.          0.          2.          0.    6694.50
       .02        .61      3.26         .00        .100      .040        .100        .000    6684.40     38.96
   .001099        85.       85.         85.           2         0           0         .00     183.08     242.42


*SECNO 8.000
      8.00       4.92   6689.82         .00         .00   6690.06         .24         .06         .01   6694.00
     1000.         0.     1000.          0.          0.      255.          0.          2.          1.    6694.00
       .02        .00      3.93         .00        .100      .040        .100        .000    6684.90     43.08
   .001822        40.       40.         40.           2         0           0         .00      63.29     106.37


*SECNO 9.000
      9.00       4.63   6689.83         .00         .00   6690.11         .28         .04         .00   6693.00
     1000.         0.      998.          2.          0.      236.          5.          2.          1.    6689.50
       .02        .00      4.23         .33        .100      .040        .100        .000    6685.20     63.72
   .002208        20.       20.         20.           2         0           0         .00      77.60     141.32


*SECNO 10.000
3280 CROSS SECTION     10.00 EXTENDED        .05 FEET

     10.00       4.15   6690.04         .00         .00   6690.23         .18         .09         .03   6690.50
     1000.         0.     1000.          0.          0.      290.          0.          2.          1.    6690.00
       .03        .00      3.44         .00        .100      .040        .100        .000    6685.90     54.08
   .001580        40.       30.         55.           2         0           0         .00      77.92     134.00


*SECNO 11.000
3260 CROSS SECTION     11.00 EXTENDED        .02 FEET
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 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


   11.00      4.13   6690.02       .00       .00   6690.33       .30       .08       .01   6690.00
   1000.        0.     1000.        0.        0.      227.        0.        3.        1.    6690.00
     .03       .01      4.40       .00      .100      .040      .100      .000   6685.90     54.82
 .000791       25.       40.       55.         2         0         0       .00     70.18    125.00


*SECNO 12.000
3200 CROSS SECTION      12.00 EXTENDED        .28 FEET

   12.00      4.38   6690.28       .00       .00   6690.54       .26       .20       .01   6690.00
   1000.        0.     1000.        0.        0.      245.        0.        3.        1.    6690.00
     .03       .19      4.08       .00      .100      .040      .100      .000   6685.90     38.82
 .002032       60.       75.       75.         2         0         0       .00     71.18    110.00


*SECNO 13.000
3200 CROSS SECTION      13.00 EXTENDED        .62 FEET

   13.00      4.72   6690.62       .00       .00   6690.69       .07       .09       .06   6690.00
   1000.        0.     1000.        0.        1.      485.        0.        4.        1.    6690.00
     .05       .15      2.06       .00      .100      .040      .100      .000   6685.90     31.91
 .000457      100.      100.      100.         2         0         0       .00    123.09    155.00


*SECNO 14.000
3200 CROSS SECTION      14.00 EXTENDED        .67 FEET

   14.00      4.67   6690.67       .00       .00   6690.73       .06       .05       .00   6690.00
   1000.        0.     1000.        0.        1.      504.        0.        5.        1.    6690.00
     .06       .15      1.98       .00      .100      .040      .100      .000   6686.00     34.23
 .000465       70.      100.      100.         2         0         0       .00    130.77    165.00


*SECNO 15.000
3200 CROSS SECTION      15.00 EXTENDED        .67 FEET

   15.00      3.67   6690.67       .00       .00   6690.79       .12       .05       .01   6690.00
   1000.        0.     1000.        0.        1.      253.        0.        6.        2.    6690.00
     .07       .29      2.83       .00      .100      .040      .100      .000   6687.00     50.92
 .001632       60.       65.       65.         3         0         0       .00    139.08    170.50
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN      SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID     ENDST

*SECNO 16.000
     16.00       3.62   6690.62        .00        .00   6690.87        .25        .07        .01   6693.00
     1000.         0.     1000.         0.         0.      249.         1.         6.         2.    6690.00
       .07        .00      4.01        .32       .100      .040       .100       .000    6687.00     29.36
   .002398        15.       35.       100.          2         0          0        .00      76.58    105.93

*SECNO 17.000
     17.00       3.89   6690.89        .00        .00   6691.19        .30        .31        .00   6693.00
     1000.         0.     1000.         0.         0.      229.         0.         7.         2.    6694.00
       .08        .00      4.36        .00       .100      .040       .100       .000    6687.00      4.21
   .002799       120.      120.       120.          2         0          0        .00      67.80     72.01

*SECNO 18.000
     18.00       4.17   6691.17        .00        .00   6691.55        .38        .36        .01   6762.00
     1000.         0.     1000.         0.         0.      201.         0.         7.         2.    6704.00
       .08        .00      4.98        .00       .100      .040       .100       .000    6687.00     39.99
   .003456       115.      115.       115.          2         0          0        .00      56.32     96.31

*SECNO 19.000
     19.00       4.35   6691.35        .00        .00   6691.69        .34        .13        .01   6714.00
     1000.         0.     1000.         0.         0.      212.         0.         7.         2.    6704.00
       .09        .00      4.71        .00       .100      .040       .100       .000    6687.00     45.31
   .002953        40.       40.        40.          2         0          0        .00      57.66    102.96

*SECNO 20.000
     20.00       4.15   6691.15        .00        .00   6691.87        .72        .14        .04   6695.00
     1000.         0.     1000.         0.         0.      147.         0.         7.         2.    6695.00
       .09        .00      6.81        .00       .100      .040       .100       .000    6687.00     27.70
   .008208        30.       30.        30.          2         0          0        .00      49.66     77.36
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04/14          11:21:20

TW      TOP OF DIKE AT 6692.0

   ASQ      QCOMP      ERRAC      TASQ       TCQ       TABER      NITER     DSWS      USWS     DSSNO     USSNO
     .00        .00        .00        .00        .00        .00         2  6689.831  6690.667     9.000    15.000
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                                                                                        THIS RUN EXECUTED 04/14/88    16:29:43
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION APRIL 1985
**************************************************


T1         MIDDLE CREEK RESERVOIR - PRINCIPAL SPILLWAY
T2         MEADOW DIKE ANALYSIS - 25 FT LOWER CHUTE, CREST = 6683.3
T3         MAX SPILLWAY DISCHARGE = 3250 CFS

J1  ICHECK     ING        NINV       IDIR       STRT       METRIC     HVINS      Q          WSEL       FQ

       0.          6.         0.         0. -1.000000        .00         .0         0.   6687.000      .000

J2  NPROF      IPLOT      PRFVS      XSECV      XSECH      FN         ALLDC      IBW        CHNIM      ITRACE

      5.000       .000     -1.000       .000       .000       .000       .000       .000       .000       .000
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


*PROF 5


CCHV=      .600 CEHV=      .800
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED
      1.00      4.79   6688.09   6688.09   6687.00   6690.51      2.42       .00       .00   6696.00
     1496.        0.     1496.        0.        0.      120.        0.        0.        0.   6696.00
       .00       .00     12.49       .00      .015      .015      .015      .000   6683.30       .00
   .001033        0.        0.        0.         0        10         0       .00     25.00     25.00


*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

      2.00      8.43   6690.73       .00       .00   6691.51       .78       .02       .98   6696.00
     1496.        0.     1496.        0.        0.      211.        0.        0.        0.   6696.00
       .00       .00      7.10       .00      .015      .015      .015      .000   6682.30       .00
   .000595       15.       15.       15.         7         0         0       .00     25.00     25.00


*SECNO 3.000

3301 HV CHANGED MORE THAN HVINS

      3.00      9.67   6691.77       .00       .00   6691.91       .14       .00       .39   6676.50
     1496.        0.     1496.        0.        0.      504.        0.        0.        0.   6697.00
       .01       .00      2.97       .00      .100      .030      .100      .000   6682.10     19.52
   .000300       10.       10.       10.         3         0         0       .00     74.19     92.71


CCHV=      .300 CEHV=      .100
*SECNO 4.000
      4.00      9.51   6691.81       .00       .00   6691.92       .11       .01       .01   6676.00
     1496.        0.     1496.        0.        0.      565.        0.        0.        0.   6698.00
       .00       .00      2.65       .00      .100      .040      .100      .000   6682.30     18.26
   .000276       15.       15.       15.         2         0         0       .00     78.73     96.99


*SECNO 5.000
      5.00      9.21   6691.81       .00       .00   6691.93       .12       .01       .00   6670.00
     1496.        4.     1492.        0.       14.      540.        0.        1.        0.   6700.00
       .01       .23      2.76       .00      .100      .040      .100      .000   6682.60     34.92
   .000423       20.       20.       20.         2         0         0       .00     89.78    124.70
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  SECNO      DEPTH     CWSEL      CRIWS      WSELK       EG         HV         HL        OLOSS   BANK ELEV
  Q          QLOB      QCH        QROB       ALOB        ACH        AROB       VOL       TWA   LEFT/RIGHT
  TIME       VLOB      VCH        VROB       XNL         XNCH       XNR        WTN       ELMIN       SSTA
  SLOPE      XLOBL     XLCH       XLOBR      ITRIAL      IDC        ICONT      CORAR     TOPWID      ENDST

*SECNO 6.000
     6.00       8.64   6691.84        .00        .00   6691.95        .11        .02        .00   6688.00
    1496.       179.     1316.         0.       277.      473.         0.         1.         0.    6701.50
      .01        .65      2.78        .00       .100      .040       .100       .000   6683.20      41.56
  .000436        40.       40.        40.          2         0          0        .00    176.81     218.37

*SECNO 7.000
     7.00       7.50   6691.90        .00        .00   6691.99        .10        .04        .00   6691.00
    1496.       328.     1168.         0.       444.      415.         0.         3.         1.    6694.50
      .02        .74      2.82        .00       .100      .040       .100       .000   6684.40      21.68
  .000561        85.       85.        85.          2         0          0        .00    225.41     247.09

*SECNO 8.000
     8.00       6.91   6691.81        .00        .00   6692.04        .23        .03        .01   6694.00
    1496.         0.     1496.         0.         0.      389.         0.         3.         1.    6694.00
      .02        .00      3.84        .00       .100      .040       .100       .000   6684.90      38.29
  .001200        40.       40.        40.          2         0          0        .00     72.66     110.95

*SECNO 9.000
3280 CROSS SECTION       9.00 EXTENDED       1.81 FEET

     9.00       6.62   6691.82        .00        .00   6692.06        .25        .02        .00   6693.00
    1496.         0.     1461.        34.         0.      362.        39.         4.         1.    6689.50
      .02        .00      4.03        .89       .100      .040       .100       .000   6685.20      58.89
  .001272        20.       20.        20.          2         0          0        .00     83.11     142.00

*SECNO 10.000
3280 CROSS SECTION      10.00 EXTENDED       1.97 FEET

    10.00       6.07   6691.97        .00        .00   6692.14        .17        .05        .02   6690.50
    1496.         3.     1492.         0.        10.      446.         0.         4.         1.    6690.00
      .03        .36      3.35        .00       .100      .040       .100       .000   6685.90      40.00
  .000888        40.       50.        55.          2         0          0        .00     94.00     134.00

*SECNO 11.000
3280 CROSS SECTION      11.00 EXTENDED       1.93 FEET

    11.00       6.03   6691.93        .00        .00   6692.19        .26        .04        .01   6690.00
    1496.         8.     1488.         0.        14.      361.         0.         4.         1.    6690.00
      .03        .55      4.13        .00       .100      .040       .100       .000   6685.90      40.53
  .001472        25.       40.        55.          2         0          0        .00     84.47     125.00
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK               HV        HL        OLOSS   L-BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROR      VOL       TWA   LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 12.000
3280 CROSS SECTION     12.00 EXTENDED      2.05 FEET

    12.00      6.15  6692.05       .00       .00  6692.30       .25       .11       .00  6690.00
    1496.        5.    1491.        0.        9.     369.        0.        5.        1.   6690.00
      .04       .55     4.04       .00      .100      .040      .100      .000  6685.90     31.39
  .001371       60.      75.       75.         2         0         0       .00    78.61    110.00

*SECNO 13.000
3280 CROSS SECTION     13.00 EXTENDED      2.35 FEET

    13.00      6.45  6692.35       .00       .00  6692.42       .07       .06       .05  6690.00
    1496.        4.    1492.        0.       14.     692.        0.        6.        1.   6690.00
      .05       .30     2.16       .00      .100      .040      .100      .000  6685.90     23.27
  .000338      100.     100.      100.         2         0         0       .00   131.73    155.00

*SECNO 14.000
3280 CROSS SECTION     14.00 EXTENDED      2.38 FEET

    14.00      6.39  6692.39       .00       .00  6692.45       .07       .03       .00  6690.00
    1496.        3.    1493.        0.       12.     724.        0.        8.        2.   6690.00
      .06       .29     2.06       .00      .100      .040      .100      .000  6686.00     27.20
  .000317       70.     100.      100.         2         0         0       .00   137.80    165.00

*SECNO 15.000
3280 CROSS SECTION .   15.00 EXTENDED      2.39 FEET

    15.00      5.38  6692.38       .00       .00  6692.45       .10       .03       .00  6690.00
    1500.        8.    1492.        0.       17.     585.        0.        9.        2.   6690.00
      .07       .43     2.55       .00      .100      .040      .100      .000  6687.00     40.41
  .000685       60.      65.       65.         2         0         0       .00   149.57    190.00

*SECNO 16.000
    16.00      5.29  6692.29       .00       .00  6692.53       .24       .03       .01  6693.00
    1500.        0.    1495.        5.        0.     376.        8.        9.        2.   6690.00
      .07       .00     3.97       .60      .100      .040      .100      .000  6687.00     26.31
  .001447       15.      35.      100.         2         0         0       .00    84.78    111.09
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     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         QLOSS    BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

*SECNO 17.000
      17.00       5.44   6692.44        .00        .00   6692.74        .30        .20        .01   6693.00
      1500.         0.     1500.         0.         0.      339.         0.        10.         2.    6694.00
        .04        .00      4.42        .00       .100      .040       .100       .000    6687.00       1.13
    .001962       120.      120.       120.          2         0          0        .00      74.86      75.98

*SECNO 18.000
      18.00       5.59   6692.59        .00        .00   6693.02        .43        .27        .01   6762.00
      1500.         0.     1500.         0.         0.      285.         0.        11.         2.    6704.00
        .09        .00      5.27        .00       .100      .040       .100       .000    6687.00      37.95
    .002791       115.      115.       115.          2         0          0        .00      61.86      99.81

*SECNO 19.000
      19.00       5.74   6692.74        .00        .00   6693.14        .40        .11        .01   6714.00
      1500.         0.     1500.         0.         0.      296.         0.        11.         2.    6704.00
        .05        .00      5.06        .00       .100      .040       .100       .000    6687.00      42.62
    .002504        40.       40.        40.          2         0          0        .00      63.29     105.81

*SECNO 20.000
      20.00       5.57   6692.57        .00        .00   6693.27        .71        .11        .03   6695.00
      1500.         0.     1500.         0.         0.      223.         0.        12.         2.    6695.00
        .09        .00      6.74        .00       .100      .040       .100       .000    6687.00      24.66
    .005606        30.       30.        30.          2         0          0        .00      57.16      82.02
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TW      TOP OF DIKE AT 6692.

    ARQ       QCOMP      ERRAC      TASQ       TCQ       TABER      NITER     DSWS      USWS      DSSNO      USSNO
     4.08       4.12       1.00       4.08       4.12       1.00          5  6691.817  6692.384      9.000     15.000
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                                                                                   THIS RUN EXECUTED 04/14/88    16:32:25
***************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION APRIL 1985
***************************************************


T1         MIDDLE CREEK RESERVOIR - PRINCIPAL SPILLWAY
T2         MEADOW DIKE ANALYSIS - 25 FT LOWER CHUTE, CREST = 6683.3
T3         MAX SPILLWAY DISCHARGE = 3250 CFS

J1   ICHECK     INQ       NINV       IDIR       STRT      METRIC     HVINS       Q        WSEL       FQ

        0.         7.        0.         0. -1.000000       .00        .0        0.  6637.000      .000

J2   NPROF      IPLOT     PRFVS      XSECV      XSECH       FN       ALLDC      IBW       CHNIM     ITRACE

      6.000      .000    -1.000       .000       .000      .000      .000      .000      .000      .000
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     SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
     Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
     TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN       SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST


*PROF 6


CCHV=      .600 CEHV=      .800
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED
      1.00       5.08  6688.38  6688.38  6687.00  6690.94       2.57        .00        .00  6696.00
     1631.         0.     1631.       0.       0.     127.         0.         0.         0.   6696.00
       .00        .00     12.85      .00     .015     .015       .015       .000   6683.30       .00
   .003040         0.        0.       0.        0       10          0        .00     25.00     25.00


*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

      2.00       8.84  6691.14      .00      .00  6691.99        .85        .02       1.03  6696.00
     1631.         0.     1631.       0.       0.     221.         0.         0.         0.   6696.00
       .00        .00      7.38      .00     .015     .015       .015       .000   6682.30       .00
   .000620        15.       15.      15.        7        0          0        .00     25.00     25.00


*SECNO 3.000

3301 HV CHANGED MORE THAN HVINS

      3.00      10.18  6692.28      .00      .00  6692.42        .14        .00        .42  6696.50
     1631.         0.     1631.       0.       0.     542.         0.         0.         0.   6697.00
       .00        .00      3.01      .00     .100     .030       .100       .000   6682.10     17.39
   .000292        10.       10.      10.        3        0          0        .00     76.52     93.90


CCHV=      .300 CEHV=      .100
*SECNO 4.000
      4.00      10.02  6692.32      .00      .00  6692.43        .11        .01        .01  6696.00
     1631.         0.     1631.       0.       0.     605.         0.         0.         0.   6698.00
       .00        .00      2.70      .00     .100     .040       .100       .000   6682.30     17.25
   .000387        15.       15.      15.        2        0          0        .00     80.80     98.06


*SECNO 5.000
      5.00       9.72  6692.32      .00      .00  6692.44        .12        .01        .00  6690.00
     1631.         7.     1624.       0.      22.     578.         0.         1.         0.   6700.00
       .01        .33      2.81      .00     .100     .040       .100       .000   6682.60     30.60
   .000408        20.       20.      20.        2        0          0        .00     95.22    125.90
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN        SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID       ENDST


*SECNO 6.000
     6.00      9.16   6692.36       .00       .00   6692.46       .10       .02       .01   6688.00
    1631.      226.     1405.        0.      335.      508.        0.        1.        0.    6701.50
      .01       .68      2.77       .00      .100      .040      .100      .000   6683.20     36.41
  .000402       40.       40.       40.         2         0         0.      .00    183.11    219.52


*SECNO 7.000
     7.00      8.01   6692.41       .00       .00   6692.50       .09       .04       .00   6691.00
    1631.      397.     1234.        0.      525.      451.        0.        3.        1.    6694.50
      .02       .76      2.74       .00      .100      .040      .100      .000   6684.40     18.07
  .000466       85.       85.       85.         2         0         0       .00    230.19    248.26


*SECNO 8.000
     8.00      7.42   6692.32       .00       .00   6692.54       .23       .03       .01   6694.00
    1631.        0.     1631.        0.        0.      427.        0.        4.        1.    6694.00
      .02       .00      3.82       .00      .100      .040      .100      .000   6684.90     37.06
  .001098       40.       40.       40.         2         0         0       .00     75.06    112.12


*SECNO 9.000
3280 CROSS SECTION       9.00 EXTENDED       2.32 FEET

     9.00      7.13   6692.33       .00       .00   6692.57       .24       .02       .00   6693.00
    1631.        0.     1586.       45.        0.      396.       47.        4.        1.    6689.50
      .02       .00      4.00       .95      .100      .040      .100      .000   6685.20     57.65
  .001140       20.       20.       20.         2         0         0       .00     84.35    142.00


*SECNO 10.000
3290 CROSS SECTION      10.00 EXTENDED       2.47 FEET

    10.00      6.56   6692.46       .00       .00   6692.64       .17       .05       .02   6690.50
    1631.        7.     1624.        0.       17.      486.        0.        4.        1.    6690.00
      .03       .41      3.34       .00      .100      .040      .100      .000   6685.90     35.59
  .000794       40.       50.       55.         2         0         0       .00     98.41    134.00


*SECNO 11.000
3280 CROSS SECTION      11.00 EXTENDED       2.43 FEET

    11.00      6.53   6692.43       .00       .00   6692.68       .26       .04       .01   6690.00
    1631.       13.     1618.        0.       22.      395.        0.        5.        1.    6690.00
      .03       .60      4.09       .00      .100      .040      .100      .000   6685.90     36.80
  .001292       25.       40.       55.         2         0         0       .00     88.20    125.00
```

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 04/14 88     10:21:

   SECNO       DEPTH       CWSEL       CRIWS       WSELK       EG          HV          HL          QLOSS     BANK ELEV
   Q           QLOB        QCH         QROB        ALOB        ACH         AROB        VOL         TWA     LEFT/RIGHT
   TIME        VLOB        VCH         VROB        XNL         XNCH        XNR         WTN         ELMIN        SSTA
   SLOPE       XLOBL       XLCH        XLOBR       ITRIAL      IDC         ICONT       CORAR       TOPWID       ENDST

*SECNO 12.000
3280 CROSS SECTION      12.00 EXTENDED       2.53 FEET

     12.00        6.63  6692.53         .00         .00  6692.78         .25         .09         .00  6690.00
     1631.          8.    1623.          0.         13.     402.          0.          6.          1.   6690.00
       .04         .60     4.03         .00        .100      .040        .100        .000     6685.90     29.38
   .001226         60.      75.         75.           2         0           0         .00       80.62    110.00

*SECNO 13.000
3280 CROSS SECTION      13.00 EXTENDED       2.82 FEET

     13.00        6.92  6692.82         .00         .00  6692.89         .07         .05         .05  6690.00
     1631.          6.    1625.          0.         20.     749.          0.          7.          1.   6690.00
       .05         .32     2.17         .00        .100      .040        .100        .000     6685.90     20.92
   .000310        100.     100.        100.           2         0           0         .00      134.08    155.00

*SECNO 14.000
3280 CROSS SECTION      14.00 E/TENDED       2.85 FEET

     14.00        6.85  6692.85         .00         .00  6692.92         .07         .03         .00  6690.00
     1631.          5.    1626.          0.         17.     784.          0.          9.          2.   6690.00
       .06         .31     2.07         .00        .100      .040        .100        .000     6686.00     25.26
   .000290         70.     100.        100.           2         0           0         .00      139.74    165.00

*SECNO 15.000
3280 CROSS SECTION  .   15.00 EXTENDED       2.82 FEET

     15.00        5.81  6692.81         .00         .00  6692.96         .15         .03         .01  6690.00
     2000.         13.    1987.          0.         24.     613.          0.         10.          2.   6690.00
       .07         .55     3.09         .00        .100      .040        .100        .000     6687.00     37.77
   .000880         60.      65.         65.           2         0           0         .00      152.23    190.00

*SECNO 16.000
     16.00        5.66  6692.66         .00         .00  6693.03         .37         .05         .02  6693.00
     2000.          0.    1991.          9.          0.     405.         1.         10.          2.   6690.00
       .07         .00     4.92         .73        .100      .040        .100        .000     6687.00     25.63
   .002035         15.      35.        100.           2         0           0         .00       86.60    112.23
   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*SECNO 17.000
     17.00       5.87  6692.87        .00        .00  6693.31        .45        .28        .01  6693.00
     2000.         0.    2000.         0.         0.     372.         0.        11.         2.   6694.00
       .08        .00     5.38        .00       .100      .040       .100       .000   6687.00       .27
   .002667       120.     120.       120.          2         0          0        .00     76.82     77.09


*SECNO 18.000
     18.00       6.06  6693.06        .00        .00  6693.69        .63        .36        .02  6762.00
     2000.         0.    2000.         0.         0.     315.         0.        12.         2.   6704.00
       .08        .00     6.36        .00       .100      .040       .100       .000   6687.00     37.27
   .003710       115.     115.       115.          2         0          0        .00     63.72    100.99


*SECNO 19.000
     19.00       6.28  6693.28        .00        .00  6693.85        .56        .14        .02  6714.00
     2000.         0.    2000.         0.         0.     332.         0.        13.         2.   6704.00
       .08        .00     6.03        .00       .100      .040       .100       .000   6687.00     11.43
   .003215        40.      40.        40.          2         0          0        .00     65.51    106.94


*SECNO 20.000
     20.00       6.04  6693.04        .00        .00  6694.03        .97        .14        .04  6695.00
     2000.         0.    2000.         0.         0.     250.         0.        13.         2.   6695.00
       .08        .00     8.00        .00       .100      .040       .100       .000   6687.00     23.92
   .007177        30.      30.        30.          2         0          0        .00     59.64     83.56
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[illegible]

TW      TOP OF DIKE AT 6692.0

   ASQ      QCOMP      ERRAC      TASQ       TCQ       TABER      NITER      DSWS       USWS       DSSNO      USSNO
 368.93    368.97        .01     368.93    368.97        .01          7   6692.327   6692.814      9.000     15.000
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                                                                                   THIS RUN EXECUTED 04/14/88    16:35:44
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION APRIL 1985
**************************************************


T1         MIDDLE CREEK RESERVOIR - PRINCIPAL SPILLWAY
T2         MEADOW DIKE ANALYSIS - 25 FT LOWER CHUTE, CREST = 6683.3
T3         MAX SPILLWAY DISCHARGE = 3250 CFS

J1   ICHECK     INQ       NINV      IDIR       STRT      METRIC    HVINS      Q         WSEL       FQ

        0.        8.        0.        0.  -1.000000       .00        .0        0.  6687.000       .000

J2   NPROF     IFLOT     PRFVS     XSECV      XSECH      FN        ALLDC      IBW      CHNIM      ITRACE

     15.000      .000    -1.000      .000      .000      .000      .000      .000      .000      .000
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


*PROF 7


CCHV=     .600 CEHV=     .800
*SECNO 1.000
3720 CRITICAL DEPTH ASSUMED
      1.00      5.49   6688.79   6688.79   6687.00   6691.54      2.75       .00       .00   6696.00
     1828.        0.     1828.        0.        0.      137.        0.        0.        0.   6696.00
       .00       .00     13.31       .00      .015      .015      .015      .000   6683.30       .00
   .003028        0.        0.        0.         0        10         0       .00     25.00     25.00


*SECNO 2.000

3301 HV CHANGED MORE THAN HVINS

      2.00      9.41   6691.71       .00       .00   6692.65       .94       .02      1.09   6696.00
     1828.        0.     1828.        0.        0.      235.        0.        0.        0.   6696.00
       .00       .00      7.78       .00      .015      .015      .015      .000   6682.30       .00
   .000656       15.       15.       15.         7         0         0       .00     25.00     25.00


*SECNO 3.000

3301 HV CHANGED MORE THAN HVINS

      3.00     10.88   6692.98       .00       .00   6693.13       .15       .00       .48   6696.50
     1828.        0.     1828.        0.        0.      597.        0.        0.        0.   6697.00
       .00       .00      3.06       .00      .100      .030      .100      .000   6682.10     15.81
   .000280       10.       10.       10.         3         0         0       .00     79.76     95.57


CCHV=     .300 CEHV=     .100
*SECNO 4.000
      4.00     10.73   6693.03       .00       .00   6693.14       .12       .00       .01   6696.00
     1828.        0.     1828.        0.        0.      663.        0.        0.        0.   6698.00
       .00       .00      2.76       .00      .100      .040      .100      .000   6682.30     15.26
   .000376       15.       15.       15.         2         0         0       .00     83.68     99.5


*SECNO 5.000
      5.00     10.43   6693.03       .00       .00   6693.15       .13       .01       .00   6690.00
     1828.       15.     1813.        0.       38.      633.        0.        1.        0.   6700.00
       .00       .38      2.87       .00      .100      .040      .100      .000   6682.60     24.78
   .000388       20.       20.       20.         2         0         0       .00    102.78    127.57
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    SECNO      DEPTH      CWSEL      CRIWS      WSELK       EG         HV         HL        OLOSS   BANK ELEV
      Q        QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
    TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN       ELMIN       SSTA
    SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR     TOPWID      ENDST

*SECNO 6.000
      6.00       9.88   6693.08        .00        .00   6693.17        .10        .02        .01   6688.00
     1828.       298.     1530.         0.       420.      557.         0.         1.         0.    6701.50
       .01        .71      2.75        .00       .100      .040       .100       .000   6683.20      29.24
   .000363        40.       40.        40.          2         0          0        .00    191.89     221.13

*SECNO 7.000
      7.00       8.73   6693.13        .00        .00   6693.21        .08        .03        .01   6691.00
     1828.       497.     1331.         0.       642.      502.         0.         4.         1.    6694.50
       .02        .77      2.65        .00       .100      .040       .100       .000   6684.40      13.05
   .000406        85.       85.        85.          2         0          0        .00    236.84     249.89

*SECNO 8.000
      8.00       8.13   6693.03        .00        .00   6693.25        .22        .02        .01   6694.00
     1828.         0.     1828.         0.         0.      481.         0.         4.         1.    6694.00
       .02        .00      3.80        .00       .100      .040       .100       .000   6684.90      35.35
   .000983        40.       40.        40.          2         0          0        .00     78.41     113.76

*SECNO 9.000
3250 CROSS SECTION        9.00 EXTENDED        3.03 FEET

      9.00       7.83   6693.03        .00        .00   6693.27        .24        .02        .00   6693.00
     1828.         0.     1767.        61.         0.      445.        60.         4.         1.    6689.50
       .02        .00      3.97       1.03       .100      .040       .100       .000   6685.20      55.84
   .000998        20.       20.        20.          2         0          0        .00     86.16     142.00

*SECNO 10.000
3280 CROSS SECTION       10.00 EXTENDED        3.16 FEET

     10.00       7.26   6693.16        .00        .00   6693.33        .17        .04        .02   6690.50
     1828.        15.     1813.         0.        31.      542.         0.         5.         1.    6690.00
       .03        .47      3.34        .00       .100      .040       .100       .000   6685.90      29.42
   .000693        40.       50.        55.          2         0          0        .00    104.58     134.00

*SECNO 11.000
3280 CROSS SECTION       11.00 EXTENDED        3.12 FEET

     11.00       7.22   6693.12        .00        .00   6693.38        .25        .03        .01   6690.00
     1828.        24.     1804.         0.        37.      444.         0.         6.         1.    6690.00
       .03        .66      4.06        .00       .100      .040       .100       .000   6685.90      31.58
   .001103        23.       40.        55.          2         0          0        .00     93.42     125.00
   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    L-BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*SECNO 12.000
3280 CROSS SECTION      12.00 EXTENDED       3.21 FEET

     12.00       7.31  6693.21        .00        .00  6693.46        .25        .08        .00  6690.00
     1828.        14.    1814.         0.        22.     450.         0.         6.         1.   6690.00
       .04        .65     4.03        .00       .100      .040       .100       .000    6685.90     26.53
   .001064        60.      75.        75.          2         0          0        .00      83.47    110.00


*SECNO 13.000
3280 CROSS SECTION      13.00 EXTENDED       3.48 FEET

     13.00       7.58  6693.48        .00        .00  6693.56        .07        .05        .05  6690.00
     1828.        11.    1817.         0.        30.     629.         0.         8.         1.   6690.00
       .05        .35     2.19        .00       .100      .040       .100       .000    6685.90     17.58
   .000278       100.     100.       100.          2         0          0        .00     137.43    155.00


*SECNO 14.000
3280 CROSS SECTION      14.00 EXTENDED       3.52 FEET

     14.00       7.52  6693.52        .00        .00  6693.59        .07        .03        .00  6690.00
     1828.         9.    1819.         0.        25.     869.         0.        10.         2.   6690.00
       .06        .34     2.09        .00       .100      .040       .100       .000    6686.00     22.53
   .000259        70.     100.       100.          2         0          0        .00     142.47    165.00


*SECNO 15.000
3280 CROSS SECTION      15.00 EXTENDED       3.34 FEET

     15.00       6.34  6693.34        .00        .00  6693.66        .31        .04        .02  6690.00
     3250.        29.    3221.         0.        34.     714.         0.        11.         2.   6690.00
       .07        .84     4.51        .00       .100      .040       .100       .000    6687.00     34.57
   .001655        60.      65.        65.          3         0          0        .00     155.43    190.00


*SECNO 16.000

3301 HV CHANGED MORE THAN HVINS

     16.00       5.92  6692.92        .00        .00  6693.81        .89        .09        .06  6693.00
     3250.         0.    3233.        17.         0.     426.        13.        12.         2.   6690.00
       .07        .00     7.59       1.25       .100      .040       .100       .000    6687.00     25.14
   .004575        15.      35.       100.          2         0          0        .00      87.91    113.06
   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*SECNO 17.000
3280 CROSS SECTION      17.00 EXTENDED        .44 FEET

     17.00       6.44  6693.44        .00        .00  6694.39        .94        .57        .01  6693.00
     3250.         0.    3250.         0.         0.     417.         0.        13.         2.   6694.00
       .07        .00     7.80        .00       .100      .040       .100      .000    6687.00       .00
   .005015       120.     120.       120.          3         0          0        .00     78.56     78.56


*SECNO 18.000
     18.00       6.83  6693.83        .00        .00  6695.06       1.24        .65        .03  6762.00
     3250.         0.    3250.         0.         0.     364.         0.        14.         2.   6704.00
       .08        .00     8.92        .00       .100      .040       .100      .000    6687.00     36.17
   .006415       115.     115.       115.          3         0          0        .00     66.70    102.87


*SECNO 19.000
     19.00       7.35  6694.35        .00        .00  6695.35       1.01        .22        .07  6714.00
     3250.         0.    3250.         0.         0.     403.         0.        14.         3.   6704.00
       .08        .00     8.06        .00       .100      .040       .100      .000    6687.00     39.31
   .004843        40.      40.        40.          3         0          0        .00     69.81    109.12


*SECNO 20.000

3301 HV CHANGED MORE THAN HVINS

     20.00       6.79  6693.79        .00        .00  6695.66       1.87        .22        .09  6675.00
     3250.         0.    3250.         0.         0.     296.         0.        14.         3.   6695.00
       .06        .00    10.96        .00       .100      .040       .100      .000    6687.00     22.41
   .011740        30.      30.        30.          3         0          0        .00     63.63     86.04
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TW      TOP OF DIKE AT 6692.0

   ASQ      QCOMP      ERRAC     TASQ       TCQ      TABER     NITER      DSWS      USWS     DSSND     USSND
 1422.04   1424.01       .14   1422.04   1424.01       .14        11  6693.035  6693.344     9.000    15.000
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                                                                                      THIS RUN EXECUTED 04/14/88    16:40:27
**************************************************
  HEC2 RELEASE DATED NOV 76 UPDATED MAY  1984
  ERROR CORR -  01,02,03,04,05,06
  MODIFICATION -  50,51,52,53,54,55,56
  IBM-PC-XT VERSION APRIL 1985
**************************************************

NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST

  MAX SPILLWAY DISCHARGE

SUMMARY PRINTOUT TABLE  150

       SECNO      XLCH      ELTRD      ELLC      ELMIN        Q       CWSEL     CRIWS       EG      10K*S      VCH       AREA      .01K

*      1.000       .00       .00       .00     6683.30    100.00   6684.09   6684.09   6684.49    38.89      5.07      19.74     16.04
*      1.000       .00       .00       .00     6683.30    500.00   6685.61   6685.61   6686.77    31.31      8.65      57.78     89.35
*      1.000       .00       .00       .00     6683.30    750.00   6686.33   6686.33   6687.85    30.54      9.91      75.66    135.72
*      1.000       .00       .00       .00     6683.30   1000.00   6686.95   6686.95   6688.81    30.57     10.95      91.32    180.87
*      1.000       .00       .00       .00     6683.30   1495.92   6688.09   6688.09   6690.51    30.33     12.47     119.78    271.64
*      1.000       .00       .00       .00     6683.30   1631.07   6688.38   6688.38   6690.94    30.40     12.85     126.89    295.83
*      1.000       .00       .00       .00     6683.30   1827.96   6688.79   6688.79   6691.54    30.28     13.31     137.32    332.20

       2.000     15.00       .00       .00     6682.30    100.00   6684.66       .00   6684.71     1.18      1.70      58.94     92.1[illegible]
       2.000     15.00       .00       .00     6682.30    500.00   6687.04       .00   6687.32     3.51      4.23     118.31    266.7[illegible]
       2.000     15.00       .00       .00     6682.30    750.00   6688.12       .00   6688.53     4.30      5.15     145.53    361.69
       2.000     15.00       .00       .00     6682.30   1000.00   6689.08       .00   6689.62     4.92      5.90     169.52    450.67
       2.000     15.00       .00       .00     6682.30   1495.92   6690.73       .00   6691.51     5.96      7.1[illegible]    210.63    612.6[illegible]
       2.000     15.00       .00       .00     6682.30   1631.07   6691.14       .00   6691.99     6.20      7.30     220.95    655.11
       2.000     15.00       .00       .00     6682.30   1827.96   6691.71       .00   6692.65     6.56      [illegible]   [illegible]   71[illegible]

       3.000     10.00       .00       .00     6682.10    100.00   6684.71       .00   6684.72     1.64      1.07      93.[illegible]    78.0[illegible]
       3.000     10.00       .00       .00     6682.10    500.00   6687.36       .00   6687.44     3.36      2.26     [illegible]   [illegible]
       3.000     10.00       .00       .00     6682.10    750.00   6688.62       .00   6688.72     3.40      2.56     293.26    406.8[illegible]
       3.000     10.00       .00       .00     6682.10   1000.00   6689.76       .00   6689.88     3.28      2.74     364.71    552.0[illegible]
       3.000     10.00       .00       .00     6682.10   1495.92   6691.77       .00   6691.91     3.00      2.97     503.68    683.41
       3.000     10.00       .00       .00     6682.10   1631.07   6692.28       .00   6692.42     2.97      3.01     [illegible]   755.[illegible]
       3.000     10.00       .00       .00     6682.10   1827.96   6692.98       .00   6693.13     2.80      3.06     597.34   1091.5[illegible]

       4.000     15.00       .00       .00     6682.30    100.00   6684.71       .00   6684.73     2.25       .92     108.[illegible]   [illegible]
       4.000     15.00       .00       .00     6682.30    500.00   6687.37       .00   6687.45     4.24      1.95     256.5[illegible]   [illegible]
       4.000     15.00       .00       .00     6682.30    750.00   6688.66       .00   6688.74     4.33      2.23     336.7[illegible]   [illegible]
       4.000     15.00       .00       .00     6682.30   1000.00   6689.80       .00   6689.89     4.23      2.41     414.[illegible]   43[illegible].17
       4.000     15.00       .00       .00     6682.30   1495.92   6691.81       .00   6691.92     3.96      2.65     554.[illegible]   [illegible]
       4.000     15.00       .00       .00     6682.30   1631.07   6692.32       .00   6692.43     3.87      2.70     605.17    [illegible]
       4.000     15.00       .00       .00     6682.30   1827.96   6693.03       .00   6693.14     3.76      2.76     [illegible]   74[illegible]
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   SECNO      XLCH      ELTRD      ELLC     ELMIN        Q      CWSEL     CRIWS       EG     10*KS      VCH      AREA      .01K

   5.000     20.00        .00       .00   6682.60    100.00   6684.72       .00   6684.73     3.52     1.07     93.36     53.28
   5.000     20.00        .00       .00   6682.60    500.00   6687.39       .00   6687.46     5.24     2.09    238.96    218.34
   5.000     20.00        .00       .00   6682.60    750.00   6688.66       .00   6688.75     5.13     2.36    318.02    331.16
   5.000     20.00        .00       .00   6682.60   1000.00   6689.81       .00   6689.90     4.89     2.53    395.00    451.7[illegible]
   5.000     20.00        .00       .00   6682.60   1495.92   6691.81       .00   6691.93     4.23     2.76    553.53    727.11
   5.000     20.00        .00       .00   6682.60   1631.07   6692.32       .00   6692.44     4.08     2.81    600.64    807.8[illegible]
   5.000     20.00        .00       .00   6682.60   1827.96   6693.03       .00   6693.15     3.88     2.87    670.68    927.5[illegible]

   6.000     40.00        .00       .00   6683.20    100.00   6684.72       .00   6684.76    10.81     1.53     65.25  [illegible]
   6.000     40.00        .00       .00   6683.20    500.00   6687.39       .00   6687.49     8.58     2.50    200.36    170.6[illegible]
   6.000     40.00        .00       .00   6683.20    750.00   6688.66       .00   6688.77     7.35     2.71    302.50    276.5[illegible]
   6.000     40.00        .00       .00   6683.20   1000.00   6689.81       .00   6689.93     6.07     2.78    434.87    405.76
   6.000     40.00        .00       .00   6683.20   1495.92   6691.84       .00   6691.95     4.36     2.78    749.85    716.24
   6.000     40.00        .00       .00   6683.20   1631.07   6692.36       .00   6692.46     4.02     2.77    842.55    813.1[illegible]
   6.000     40.00        .00       .00   6683.20   1827.96   6693.08       .00   6693.17     3.63     2.75    976.96  [illegible]

   7.000     85.00        .00       .00   6684.40    100.00   6684.97   6684.97   6685.25   290.07     4.26     23.50  [illegible]
   7.000     85.00        .00       .00   6684.40    500.00   6687.42       .00   6687.62    26.16     3.59    139.43     97.[illegible]
   7.000     85.00        .00       .00   6684.40    750.00   6688.69       .00   6688.87    16.67     3.51    247.30    183.6[illegible]
   7.000     85.00        .00       .00   6684.40   1000.00   6689.85       .00   6690.00    10.97     3.26    428.36    301.64
   7.000     85.00        .00       .00   6684.40   1495.92   6691.90       .00   6691.99     5.61     2.82    858.43    631.[illegible]
   7.000     85.00        .00       .00   6684.40   1631.07   6692.41       .00   6692.50     4.86     2.74    976.00    749.1[illegible]
   7.000     85.00        .00       .00   6684.40   1827.96   6693.13       .00   6693.21     4.08     2.65   1143.27  [illegible]

   8.000     40.00        .00       .00   6684.90    100.00   6685.73       .00   6685.85    80.59     2.85     35.0[illegible]     11.14
   8.000     40.00        .00       .00   6684.90    500.00   6687.49       .00   6687.76    43.29     4.19    119.44     76.00
   8.000     40.00        .00       .00   6684.90    750.00   6688.71       .00   6688.96    29.35     4.01  [illegible]  [illegible]
   8.000     40.00        .00       .00   6684.90   1000.00   6689.82       .00   6690.06    18.22     3.93    254.54  [illegible]
   8.000     40.00        .00       .00   6684.90   1495.92   6691.81       .00   6692.04    12.00     3.81    389.29    431.61
   8.000     40.00        .00       .00   6684.90   1631.07   6692.32       .00   6692.54    10.98     3.82    426.87    492.50
   8.000     40.00        .00       .00   6684.90   1827.96   6693.03       .00   6693.25     9.83     3.80    481.24    533.09

   9.000     20.00        .00       .00   6685.20    100.00   6685.89       .00   6686.07   154.00     3.49  [illegible]  [illegible]
   9.000     20.00        .00       .00   6685.20    500.00   6687.52       .00   6687.87    62.40   [illegible]  [illegible]  [illegible]
   9.000     20.00        .00       .00   6685.20    750.00   6688.72       .00   6689.02    33.41     4.40  [illegible]    127.7[illegible]
   9.000     20.00        .00       .00   6685.20   1000.00   6689.83       .00   6690.11    22.28     4.23    241.31  [illegible]
   9.000     20.00        .00       .00   6685.20   1495.92   6691.82       .00   6692.06    12.72     4.03    401.30  [illegible]
   9.000     20.00        .00       .00   6685.20   1631.07   6692.33       .00   6692.57    11.40     4.00    443.95  [illegible]
   9.000     20.00        .00       .00   6685.20   1827.96   6693.03       .00   6693.27     9.98     3.97    504.32    578.74

  10.000     50.00        .00       .00   6685.90    100.00   6686.56       .00   6686.65    22.75     2.47     40.14  [illegible]
  10.000     50.00        .00       .00   6685.90    500.00   6687.95       .00   6688.17    43.99     3.76    133.10     73.36
  10.000     50.00        .00       .00   6685.90    750.00   6688.99       .00   6689.19    21.26  [illegible]    209.11  [illegible]
  10.000     50.00        .00       .00   6685.90   1000.00   6690.04       .00   6690.23    15.80     3.44    290.47    231.5[illegible]
  10.000     50.00        .00       .00   6685.90   1495.92   6691.97       .00   6692.14     8.83     3.38    455.24  [illegible]
  10.000     50.00        .00       .00   6685.90   1631.07   6692.46       .00   6692.64     7.94     3.34    503.10    573.9[illegible]
  10.000     50.00        .00       .00   6685.90   1827.96   6693.16       .00   6693.33     6.93     3.34    573.82    694.16
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   SECNO      XLCH     ELTRD      ELLC     ELMIN        Q      CWSEL     CRIWS        EG     10K*S       VCH      AREA      .01K

  11.000     40.00       .00       .00   6685.90   100.00   6686.83       .00   6686.92     55.95      2.50     40.05     13.37
  11.000     40.00       .00       .00   6685.90   500.00   6688.04       .00   6688.41     77.71      4.88    102.44     56.72
  11.000     40.00       .00       .00   6685.90   750.00   6688.99       .00   6689.34     47.68      4.72    158.80    108.62
  11.000     40.00       .00       .00   6685.90  1000.00   6690.02       .00   6690.33     29.91      4.40    227.18    182.84
  11.000     40.00       .00       .00   6685.90  1495.92   6691.93       .00   6692.19     14.72      4.13    374.47    387.90
  11.000     40.00       .00       .00   6685.90  1631.07   6692.43       .00   6692.68     12.90      4.09    417.51    454.1
  11.000     40.00       .00       .00   6685.90  1827.96   6693.12       .00   6693.38     11.03      4.06    480.60    550.35

  12.000     75.00       .00       .00   6685.90   100.00   6687.13       .00   6687.18     21.54      1.84     54.35     21.5
  12.000     75.00       .00       .00   6685.90   500.00   6688.61       .00   6688.83     33.75      3.69    135.56     86.07
  12.000     75.00       .00       .00   6685.90   750.00   6689.40       .00   6689.65     30.48      4.05    185.14    125.85
  12.000     75.00       .00       .00   6685.90  1000.00   6690.28       .00   6690.54     23.33      4.08    245.27    207.05
  12.000     75.00       .00       .00   6685.90  1495.92   6692.05       .00   6692.30     13.71      4.04    377.78    404.01
  12.000     75.00       .00       .00   6685.90  1631.07   6692.53       .00   6692.78     12.26      4.03    415.91    465.6
  12.000     75.00       .00       .00   6685.90  1827.96   6693.21       .00   6693.46     10.69      4.03    471.60    559.1

  13.000    100.00       .00       .00   6685.90   100.00   6687.27       .00   6687.28      4.49       .68    114.16     47.21
  13.000    100.00       .00       .00   6685.90   500.00   6688.95       .00   6689.00      6.10      1.73    205.27    202.37
  13.000    100.00       .00       .00   6685.90   750.00   6689.76       .00   6689.82      5.87      1.96    382.52    307.49
  13.000    100.00       .00       .00   6685.90  1000.00   6690.62       .00   6690.69      4.87      2.06    485.95    452.5
  13.000    100.00       .00       .00   6685.90  1495.92   6692.35       .00   6692.42      3.30      2.14    705.99    814.06
  13.000    100.00       .00       .00   6685.90  1631.07   6692.82       .00   6692.89      3.10      2.17    768.49    9  .37
  13.000    100.00       .00       .00   6685.90  1827.96   6693.48       .00   6693.56      2.78      2.19    859.30   1096.

  14.000    100.00       .00       .00   6686.00   100.00   6687.32       .00   6687.34      7.68       .69    101.62     36.07
  14.000    100.00       .00       .00   6686.00   500.00   6689.01       .00   6689.06      6.34      1.69    295.54    198.53
  14.000    100.00       .00       .00   6686.00   750.00   6689.83       .00   6689.88      5.76      1.89    396.05    312.89
  14.000    100.00       .00       .00   6686.00  1000.00   6690.67       .00   6690.73      4.65      1.98    505.37    463.51
  14.000    100.00       .00       .00   6686.00  1495.92   6692.39       .00   6692.45      3.17      2.06    735.17    659.95
  14.000    100.00       .00       .00   6686.00  1631.07   6692.85       .00   6692.92      2.90      2.07    800.37    958.11
  14.000    100.00       .00       .00   6686.00  1827.96   6693.52       .00   6693.59      2.59      2.09    894.3    1135.

* 15.000     65.00       .00       .00   6687.00   100.00   6687.81   6687.81   6688.01    321.36      3.63     27.52      5.60
  15.000     65.00       .00       .00   6687.00   500.00   6688.97       .00   6689.17     71.96      3.63    136.77  [illegible]
  15.000     65.00       .00       .00   6687.00   750.00   6689.81       .00   6689.97     32.54      3.16    237.44    121.47
  15.000     65.00       .00       .00   6687.00  1000.00   6690.67       .00   6690.79     16.32      2.83    354.04    247.54
  15.000     65.00       .00       .00   6687.00  1500.00   6692.38       .00   6692.46      6.85      2.55    601.32    573.00
  15.000     65.00       .00       .00   6687.00  2000.00   6692.81       .00   6692.96      8.88      3.09    667.47  [illegible]
  15.000     65.00       .00       .00   6687.00  3250.00   6693.34       .00   6693.66     16.58      4.51    745.07    798.20

  16.000     35.00       .00       .00   6687.00   100.00   6688.15       .00   6688.18     11.71      1.36     73.76  [illegible]
  16.000     35.00       .00       .00   6687.00   500.00   6689.16       .00   6689.35     35.58      3.51    142.32     33.32
  16.000     35.00       .00       .00   6687.00   750.00   6689.85       .00   6690.08     31.10      3.5     17 .1     134.50
  16.000     35.00       .00       .00   6687.00  1000.00   6690.62       .00   6690.87     23.96      4.01    250.54    204.21
  16.000     35.00       .00       .00   6687.00  1500.00   6692.29       .00   6692.53     14.47      3.7     324.2     394.31
  16.000     35.00       .00       .00   6687.00  2000.00   6692.66       .00   6693.03     20.35      4.92    415.76    443.32
  16.000     35.00       .00       .00   6687.00  3250.00   6692.92       .00   6693.81     45.75  [illegible] 439.07    456.48
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SECNO	XLCH	ELTRD	ELLC	ELMIN	Q	CWSEL	CRIWS	EG	10K*S	VCH	AREA	.01K
17.000	120.00	.00	.00	6687.00	100.00	6688.29	.00	6688.32	12.09	1.47	68.22	28.76
17.000	120.00	.00	.00	6687.00	500.00	6689.55	.00	6689.74	30.00	3.51	142.32	91.29
17.000	120.00	.00	.00	6687.00	750.00	6690.20	.00	6690.46	30.91	4.09	183.58	134.87
17.000	120.00	.00	.00	6687.00	1000.00	6690.89	.00	6691.19	27.99	4.36	229.39	[illegible]
17.000	120.00	.00	.00	6687.00	1500.00	6692.44	.00	6692.74	19.62	4.42	339.46	[illegible]
17.000	120.00	.00	.00	6687.00	2000.00	6692.87	.00	6693.31	26.67	5.38	372.01	[illegible]
17.000	120.00	.00	.00	6687.00	3250.00	6693.44	.00	6694.39	50.15	7.80	416.68	450.97
18.000	115.00	.00	.00	6687.00	100.00	6688.43	.00	6688.47	13.48	1.64	61.01	[illegible]
18.000	115.00	.00	.00	6687.00	500.00	6689.87	.00	6690.10	31.29	3.81	131.06	[illegible]
18.000	115.00	.00	.00	6687.00	750.00	6690.52	.00	6690.84	34.83	4.54	163.37	[illegible]
18.000	115.00	.00	.00	6687.00	1000.00	6691.17	.00	6691.55	34.58	4.98	200.93	[illegible]
18.000	115.00	.00	.00	6687.00	1500.00	6692.59	.00	6693.02	27.91	5.27	284.63	[illegible]
18.000	115.00	.00	.00	6687.00	2000.00	6693.06	.00	6693.69	37.10	6.36	314.58	[illegible]
18.000	115.00	.00	.00	6687.00	3250.00	6693.83	.00	6695.06	64.15	8.92	344.29	[illegible]
19.000	40.00	.00	.00	6687.00	100.00	6688.48	.00	6688.52	11.78	1.57	[illegible]	[illegible]
19.000	40.00	.00	.00	6687.00	500.00	6690.02	.00	6690.32	26.17	3.59	139.28	[illegible]
19.000	40.00	.00	.00	6687.00	750.00	6690.70	.00	6690.98	29.23	4.27	175.74	[illegible]
19.000	40.00	.00	.00	6687.00	1000.00	6691.35	.00	6691.69	29.53	4.71	212.46	[illegible]
19.000	40.00	.00	.00	6687.00	1500.00	6692.74	.00	6693.14	25.04	5.06	296.36	[illegible]
19.000	40.00	.00	.00	6687.00	2000.00	6693.28	.00	6693.85	32.15	6.03	331.41	[illegible]
19.000	40.00	.00	.00	6687.00	3250.00	6694.35	.00	6695.35	48.43	8.06	401.16	[illegible]
20.000	30.00	.00	.00	6687.00	100.00	6688.45	.00	6688.61	81.13	3.10	32.02	[illegible]
20.000	30.00	.00	.00	6687.00	500.00	6689.88	.00	6690.30	92.00	5.68	88.06	52.13
20.000	30.00	.00	.00	6687.00	750.00	6690.51	.00	6691.16	90.76	6.44	116.40	[illegible]
20.000	30.00	.00	.00	6687.00	1000.00	6691.15	.00	6691.87	82.08	6.81	146.79	[illegible]
20.000	30.00	.00	.00	6687.00	1500.00	6692.57	.00	6693.27	56.06	6.74	212.58	200.31
20.000	30.00	.00	.00	6687.00	2000.00	6693.04	.00	6694.03	71.77	8.00	249.78	236.06
20.000	30.00	.00	.00	6687.00	3250.00	6693.79	.00	6695.66	117.40	10.96	292.45	299.95

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  MAX SPILLWAY DISCHARGE

SUMMARY PRINTOUT TABLE  150

        SECNO        Q         CWSEL     DIFWSP     DIFWSX     DIFKWS     TOPWID      XLCH

*       1.000     100.00    6684.09        .00        .00      -2.91      25.00        .00
*       1.000     500.00    6685.61       1.52        .00      -1.39      25.00        .00
*       1.000     750.00    6686.33        .72        .00       -.67      25.00        .00
*       1.000    1000.00    6686.95        .63        .00       -.05      25.00        .00
*       1.000    1495.92    6688.09       1.14        .00       1.09      25.00        .00
*       1.000    1631.07    6688.38        .28        .00       1.36      25.00        .00
*       1.000    1827.96    6688.79        .42        .00       1.79      25.00        .00

        2.000     100.00    6684.66        .00        .57        .00      25.00      15.00
        2.000     500.00    6687.04       2.38       1.43        .00      25.00      15.00
        2.000     750.00    6688.12       1.08       1.79        .00      25.00      15.00
        2.000    1000.00    6689.08        .96       2.13        .00      25.00      15.00
        2.000    1495.92    6690.73       1.65       2.64        .00      25.00      15.00
        2.000    1631.07    6691.14        .41       2.77        .00      25.00      15.00
        2.000    1827.96    6691.71        .57       2.92        .00      25.00      15.00

        3.000     100.00    6684.71        .00        .04        .00      41.91      10.00
        3.000     500.00    6687.36       2.65        .32        .00      54.06      10.00
        3.000     750.00    6688.62       1.26        .50        .00      59.84      10.00
        3.000    1000.00    6689.76       1.14        .68        .00      65.07      10.00
        3.000    1495.92    6691.77       2.00       1.04        .00      74.19      10.00
        3.000    1631.07    6692.28        .51       1.13        .00      76.52      10.00
        3.000    1827.96    6692.98        .71       1.27        .00      79.76      10.00

        4.000     100.00    6684.71        .00        .01        .00      49.83      15.00
        4.000     500.00    6687.39       2.68        .03        .00      60.74      15.00
        4.000     750.00    6688.66       1.27        .04        .00      65.90      15.00
        4.000    1000.00    6689.80       1.14        .04        .00      70.56      15.00
        4.000    1495.92    6691.81       2.01        .04        .00      78.73      15.00
        4.000    1631.07    6692.32        .51        .04        .00      80.80      15.00
        4.000    1827.96    6693.03        .71        .04        .00      83.68      15.00

        5.000     100.00    6684.72        .00        .00        .00      48.70      20.00
        5.000     500.00    6687.39       2.68        .00        .00      59.71      20.00
        5.000     750.00    6688.66       1.27        .00        .00      64.93      20.00
        5.000    1000.00    6689.81       1.14        .00        .00      69.64      20.00
        5.000    1495.92    6691.81       2.00        .00        .00      89.78      20.00
        5.000    1631.07    6692.32        .51        .00        .00      95.22      20.00
        5.000    1827.96    6693.03        .71        .00        .00     102.78      20.00

        6.000     100.00    6684.72        .00        .01        .00      45.64      40.00
        6.000     500.00    6687.39       2.67        .00        .00      55.52      40.00
        6.000     750.00    6688.66       1.27        .00        .00     107.19      40.00
        6.000    1000.00    6689.81       1.15        .01        .00     123.53      40.00
        6.000    1495.92    6691.84       2.03        .03        .00     176.81      40.00
        6.000    1631.07    6692.36        .52        .04        .00     183.11      40.00
        6.000    1827.96    6693.08        .72        .05        .00     191.89      40.00
        SECNO         Q       CWSEL     DIFWSP     DIFWSX     DIFKWS     TOPWID       XLCH

*       7.000    100.00     6684.97        .00        .25        .00      42.34      85.00
        7.000    500.00     6687.42       2.45        .03        .00      52.36      85.00
        7.000    750.00     6688.69       1.27        .02        .00     127.60      85.00
        7.000   1000.00     6689.85       1.16        .04        .00     183.08      85.00
        7.000   1495.92     6691.90       2.05        .05        .00     225.41      85.00
        7.000   1631.07     6692.41        .52        .05        .00     230.19      85.00
        7.000   1827.96     6693.13        .72        .06        .00     236.84      85.00

        8.000    100.00     6685.73        .00        .75        .00      43.95      40.00
        8.000    500.00     6687.49       1.76        .07        .00      52.24      40.00
        8.000    750.00     6688.71       1.22        .02        .00      58.03      40.00
        8.000   1000.00     6689.82       1.11       -.02        .00      63.29      40.00
        8.000   1495.92     6691.81       1.98       -.09        .00      72.66      40.00
        8.000   1631.07     6692.32        .51       -.09        .00      75.06      40.00
        8.000   1827.96     6693.03        .71       -.10        .00      78.41      40.00

        9.000    100.00     6685.89        .00        .16        .00      43.28      20.00
        9.000    500.00     6687.52       1.64        .04        .00      51.08      20.00
        9.000    750.00     6688.72       1.20        .01        .00      56.78      20.00
        9.000   1000.00     6689.83       1.11        .01        .00      77.60      20.00
        9.000   1495.92     6691.82       1.99        .01        .00      83.11      20.00
        9.000   1631.07     6692.33        .51        .01        .00      84.35      20.00
        9.000   1827.96     6693.03        .71        .01        .00      86.16      20.00

       10.000    100.00     6686.56        .00        .67        .00      63.15      50.00
       10.000    500.00     6687.95       1.39        .42        .00      69.90      50.00
       10.000    750.00     6688.99       1.05        .27        .00      74.97      50.00
       10.000   1000.00     6690.04       1.05        .21        .00      79.92      50.00
       10.000   1495.92     6691.97       1.92        .15        .00      94.00      50.00
       10.000   1631.07     6692.46        .50        .14        .00      98.41      50.00
       10.000   1827.96     6693.16        .70        .13        .00     104.58      50.00

       11.000    100.00     6686.83        .00        .27        .00      46.76      40.00
       11.000    500.00     6688.04       1.21        .09        .00      55.67      40.00
       11.000    750.00     6688.99        .95        .00        .00      62.64      40.00
       11.000   1000.00     6690.02       1.03       -.02        .00      70.18      40.00
       11.000   1495.92     6691.93       1.90       -.04        .00      84.47      40.00
       11.000   1631.07     6692.43        .50       -.04        .00      88.20      40.00
       11.000   1827.96     6693.13        .70       -.04        .00      93.42      40.00

       12.000    100.00     6687.13        .00        .30        .00      48.94      75.00
       12.000    500.00     6688.61       1.49        .57        .00      59.86      75.00
       12.000    750.00     6689.40        .78        .40        .00      65.64      75.00
       12.000   1000.00     6690.28        .88        .25        .00      71.18      75.00
       12.000   1495.92     6692.05       1.77        .12        .00      76.61      75.00
       12.000   1631.07     6692.53        .48        .10        .00      80.62      75.00
       12.000   1827.96     6693.21        .68        .08        .00      83.47      75.00
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   SELNO        Q       CWSEL    DIFWSP    DIFWSX    DIFKWS    TOPWID      XLCH

   13.000    100.00    6687.27      .00       .14       .00     96.92    100.00
   13.000    500.00    6688.95     1.68       .33       .00    111.13    100.00
   13.000    750.00    6689.76      .81       .37       .00    118.00    100.00
   13.000   1000.00    6690.62      .86       .34       .00    123.09    100.00
   13.000   1495.92    6692.35     1.73       .30       .00    131.73    100.00
   13.000   1631.07    6692.82      .47       .29       .00    134.08    100.00
   13.000   1827.96    6693.48      .67       .28       .00    137.43    100.00

   14.000    100.00    6687.32      .00       .05       .00    105.49    100.00
   14.000    500.00    6689.01     1.69       .06       .00    120.81    100.00
   14.000    750.00    6689.83      .81       .06       .00    126.73    100.00
   14.000   1000.00    6690.67      .85       .05       .00    130.77    100.00
   14.000   1495.92    6692.39     1.71       .04       .00    137.80    100.00
   14.000   1631.07    6692.85      .47       .04       .00    139.74    100.00
   14.000   1827.96    6693.52      .67       .04       .00    142.47    100.00

   15.000    100.00    6687.81      .00       .48       .00     68.44     65.00
   15.000    500.00    6688.97     1.16      -.05       .00    109.26     65.00
   15.000    750.00    6689.81      .85      -.02       .00    130.28     65.00
   15.000   1000.00    6690.67      .86      -.01       .00    139.08     65.00
   15.000   1500.00    6692.38     1.72       .00       .00    149.59     65.00
   15.000   2000.00    6692.81      .43      -.04       .00    152.23     65.00
   15.000   3250.00    6693.34      .53      -.18       .00    155.43     65.00

   16.000    100.00    6688.15      .00       .34       .00     66.40     35.00
   16.000    500.00    6689.16     1.01       .19       .00     70.25     35.00
   16.000    750.00    6689.85      .69       .04       .00     72.92     35.00
   16.000   1000.00    6690.62      .77      -.04       .00     76.58     35.00
   16.000   1500.00    6692.29     1.66      -.10       .00     84.78     35.00
   16.000   2000.00    6692.66      .37      -.16       .00     86.60     35.00
   16.000   3250.00    6692.92      .26      -.43       .00     87.91     35.00

   17.000    100.00    6688.29      .00       .14       .00     55.89    120.00
   17.000    500.00    6689.55     1.26       .39       .00     61.65    120.00
   17.000    750.00    6690.20      .65       .35       .00     64.64    120.00
   17.000   1000.00    6690.89      .69       .27       .00     67.80    120.00
   17.000   1500.00    6692.44     1.54       .15       .00     74.86    120.00
   17.000   2000.00    6692.87      .43       .21       .00     76.82    120.00
   17.000   3250.00    6693.44      .57       .53       .00     78.56    120.00

   18.000    100.00    6688.43      .00       .14       .00     45.58    115.00
   18.000    500.00    6689.87     1.44       .22       .00     51.24    115.00
   18.000    750.00    6690.52      .65       .32       .00     53.79    115.00
   18.000   1000.00    6691.17      .65       .28       .00     56.32    115.00
   18.000   1500.00    6692.59     1.42       .15       .00     61.86    115.00
   18.000   2000.00    6693.06      .48       .20       .00     63.72    115.00
   18.000   3250.00    6693.83      .76       .39       .00     66.70    115.00
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04/14/8[illegible]    16:21:[illegible]

    SECNO        Q        CWSEL    DIFWSP    DIFWSX    DIFKWS    TOPWID     XLCH

   19.000    100.00    6688.48       .00       .05       .00     46.01    40.00
   19.000    500.00    6690.02      1.54       .15       .00     52.26    40.00
   19.000    750.00    6690.70       .63       .17       .00     55.01    40.00
   19.000   1000.00    6691.35       .65       .18       .00     57.66    40.00
   19.000   1500.00    6692.74      1.39       .15       .00     63.29    40.00
   19.000   2000.00    6693.28       .55       .22       .00     65.51    40.00
   19.000   3250.00    6694.35      1.06       .52       .00     69.81    40.00

   20.000    100.00    6688.45       .00      -.03       .00     35.41    30.00
   20.000    500.00    6689.88      1.43      -.14       .00     42.96    30.00
   20.000    750.00    6690.51       .63      -.18       .00     46.31    30.00
   20.000   1000.00    6691.15       .63      -.20       .00     49.66    30.00
   20.000   1500.00    6692.57      1.42      -.17       .00     57.16    30.00
   20.000   2000.00    6693.04       .47      -.25       .00     59.64    30.00
   20.000   3250.00    6693.79       .75      -.56       .00     63.63    30.00
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SUMMARY OF ERRORS AND SPECIAL NOTES

CAUTION  SECNO=      1.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=      1.000  PROFILE= 2  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=      1.000  PROFILE= 3  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=      1.000  PROFILE= 4  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=      1.000  PROFILE= 5  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=      1.000  PROFILE= 6  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=      1.000  PROFILE= 7  CRITICAL DEPTH ASSUMED

CAUTION  SECNO=      7.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=      7.000  PROFILE= 1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=      7.000  PROFILE= 1  20 TRIALS ATTEMPTED TO BALANCE WSEL

CAUTION  SECNO=     15.000  PROFILE= 1  CRITICAL DEPTH ASSUMED
CAUTION  SECNO=     15.000  PROFILE= 1  PROBABLE MINIMUM SPECIFIC ENERGY
CAUTION  SECNO=     15.000  PROFILE= 1  20 TRIALS ATTEMPTED TO BALANCE WSEL
```

APPENDIX F-5

LABYRINTH WEIR

MIDDLE CREEK DAM REHABILITATION
LABYRINTH WEIR RATING CURVE

SPILLWAY CREST = 6721.0 P = 13.3
l = 140 w = 37
l/w = 3.78

WATER SURFACE ELEVATION (1)	H (2)	H/P (3)	WEIR COEFF "Ca" (4)	WEIR COEFF "Cs" (5)	(l/w) sharp (6)	TAYLOR and HAY Q1/Qn (7)	USBR Q1/Qn (8)	CALC Qn (9)	TAYLOR and HAY Q1 (10)	USBR Q1 (11)
6721.5	0.50	0.0376	3.25	3.24	3.80	3.8	3.7	42.70	160	160
6722.0	1.00	0.0752	3.30	3.25	3.84	3.8	3.6	120.78	460	430
6722.5	1.50	0.1128	3.50	3.27	4.06	4.0	3.6	222.59	890	800
6723.0	2.00	0.1504	3.57	3.28	4.12	4.0	3.6	344.02	1380	1240

COLUMN DESCRIPTIONS

(1) Reservoir water surface elevation.

(2) Total head over weir crest; Column (1) minus crest elevation.

(3) Head divided by P; P is weir height; Bottom of approach cannel at elev 6707.7

(4) Wier 'C' coefficient for shape of weir to be used.
From Brater & King, "HANDBOOK OF HYDRAULICS, 6ed" Table 5-11.
(5) Sharp crested weir coeficient; Cs = 3.22 + (.4 * H/P).

(6) Labyrinth length multiplier with crest coeeficient adjustment.
Ca/Cs*(l/w)
(7) Labyrinth flow Multiplier from Hay & Taylor, "Performance and Design of Labyrinth Weirs", Journal of the Hydraulics Division, ASCE, November 1970.
(8) Labyrinth flow Multiplier from Houston & DeAngelis, "A Site Specific Study of a Labyrinth Weir", Proceedings of 1982 ASCE Conference - Applying Research to Hydraulic Practice.
(9) Calculated flow for straight sharp-crested weir;
Q = Cs * (w - 0.003) * (H + 0.003)^1.5
(10) Labyrinth flow using Hay & Taylor flow multiplier.

(11) Labyrinth flow using USBR flow multiplier.

APPENDIX G-1

HEC-2 PRINTOUT - AUXILIARY SPILLWAY

```
*******************************************************                                        ****************************************
*  WATER SURFACE PROFILES                             *                                        *  U.S. ARMY CORPS OF ENGINEERS        *
*  VERSION OF SEPTEMBER 1988                          *                                        *  THE HYDROLOGIC ENGINEERING CENTER   *
*  ERROR: 01.02                                       *                                        *  609 SECOND STREET, SUITE D          *
*  UPDATED:  4 APRIL     1989                         *                                        *  DAVIS, CALIFORNIA 95616-4687        *
*  RUN DATE      9/13/90    TIME    10:35:51          *                                        *  (916) 756-1104, (916) 551-1748      *
*******************************************************                                        ****************************************


                                                   X     X  XXXXXXX   XXXXX              XXXXX
                                                   X     X  X        X     X            X     X
                                                   X     X  X        X                        X
                                                   XXXXXXX  XXXX     X          XXXXX    XXXXX
                                                   X     X  X        X                  X
                                                   X     X  X        X     X            X
                                                   X     X  XXXXXXX   XXXXX             XXXXXXX
END OF BANNER
```

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                                                                                       THIS RUN EXECUTED  9/13/90    10:35:51
**************************************************
  HEC2 RELEASE DATED SEP 88 UPDATED APR  1989

  ERROR CORR -  01,02
  MODIFICATION -
**************************************************

T1       MIDDLE CREEK DAM
T2       AUXILIARY SPILLWAY - FINAL DESIGN - ALTERNATIVE C
T3       HKM ASSOCIATES - 4/88

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

       0         2         0         0        -1         0       0.5         0    6715.0

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

      1                  -1                                        -1

J3  VARIABLE CODES FOR SUMMARY PRINTOUT

    150

NC      .04        .04        .04         .1          .3
QT        8        100        500       1000        5000       10000       15000       20000       27300
X1     1140          5         17        129
GR     6718          0     6714.0         17      6700.5          59      6700.5         129        6714         320

X1     1050          5         20        150          90          90          90
GR     6718          0     6717.0         20      6700.8          80      6700.8         150        6720         260

X1      972          6       30.0        202          78          78          78
GR     6720          0    6718.00       30.0     6701.00        89.0        6701       160.0        6715       202.0
GR     6730        275

X1      850          5         45        263         122         122         122
GR     6724          0       6723         45     6704.60         120     6704.60       186.0        6732         263

X1      750          6        140        283         100         100         100
GR     6735          0       6715        140      6707.4         205      6707.4         276      6707.7         283
GR   6740.0        395

X1      650          7        135        320         100         100         100           0
GR     6735          0       6730         16      6725.0         135      6710.2         197      6710.2         300
GR     6714        320       6730        363

X1      600          7         90        270          70          40          50
GR     6740          0       6732         38        6728          80        6727          90        6712         135
GR     6712        270       6730        330
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X1     480          5         73        295        130        100        120
GR    6730          0     6725.0         45     6715.0         73       6715        295       6734        356

X1     250          4         36        533        310        160        240
GR    6736          0     6721.8         36     6721.8        533     6740.0        580

X1     200          4         41        571         60         50         50
GR    6739          0     6723.0         41     6723.0        571       6732        700

X1     165          0          0          0         35         35         35

NC     .04        .04        .04         .1         .3
X1     150          7          0        780         15         15         15
GR    6736          0     6722.9         35     6722.9        370       6720        405       6720        620
GR    6721        700       6731        780

X1     100          8         43        885         50         50         50
GR    6739          0     6722.4         43     6722.4        410       6718        540       6720        600
GR    6711        800       6720        885       6731        886

X1      50         11          0        910         50         50         50
GR    6732          0     6722.4         25     6722.4        310       6713        360       6720        450
GR    6721        490       6715        550       6719        600       6705        800       6720        900
GR    6731        910
```

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    SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
    Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
    TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
    SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


 *PROF  1

 CRITICAL  DEPTH  TO  BE  CALCULATED  AT  ALL  CROSS  SECTIONS



 CCHV=      .100 CEHV=      .300
 *SECNO  1140.000
 3720  CRITICAL  DEPTH  ASSUMED
   1140.00       .39   6700.89   6700.89   6715.00   6701.08       .19       .00       .00   6714.00
      100.        0.       98.        2.        0.       28.        1.        0.        0.    6700.50
       .00       .00      3.54      2.24      .000      .040      .040      .000   6700.50     57.78
   .032166        0.        0.        0.         0        25         0       .00     76.74    134.53


 *SECNO  1050.000

 3302  WARNING:   CONVEYANCE  CHANGE  OUTSIDE  OF  ACCEPTABLE  RANGE,   KRATIO  =   3.50

   1050.00       .83   6701.63   6701.20       .00   6701.67       .04       .57       .01   6717.00
      100.        0.       98.        2.        0.       59.        2.        0.        0.    6700.80
       .02       .00      1.65      1.05      .000      .040      .040      .000   6700.80     76.93
   .002631       90.       90.       90.         5         5         0       .00     77.81    154.74


 *SECNO  972.000
    972.00       .83   6701.83   6701.39       .00   6701.88       .04       .21       .00   6718.00
      100.        0.      100.        0.        0.       61.        0.        0.        0.    6715.00
       .03       .00      1.64       .00      .000      .040      .000      .000   6701.00     86.13
   .002642       78.       78.       78.         0        14         0       .00     76.36    162.48


 *SECNO  850.000
 7185  MINIMUM  SPECIFIC  ENERGY
 3720  CRITICAL  DEPTH  ASSUMED
    850.00       .41   6705.01   6705.01       .00   6705.21       .20       .78       .05   6723.00
      100.        0.      100.        0.        0.       28.        0.        0.        1.    6732.00
       .04       .00      3.60       .00      .000      .040      .000      .000   6704.60    118.32
   .031668      122.      122.      122.         0         9         0       .00     68.83    187.16


 *SECNO  750.000
    750.00       .41   6707.81   6707.78       .00   6707.96       .15      2.74       .01   6715.00
      100.        0.      100.        0.        0.       32.        0.        0.        1.    6707.70
       .05       .00      3.10       .06      .000      .040      .040      .000   6707.40    201.43
   .024001      100.      100.      100.         2         8         0       .00     81.98    283.41
   SECNO      DEPTH     CWSEL     CRIWS     WSELK      EG        HV        HL       OLOSS   BANK ELEV
   Q          QLOB      QCH       QROB      ALOB       ACH       AROB      VOL      TWA    LEFT/RIGHT
   TIME       VLOB      VCH       VROB      XNL        XNCH      XNR       WTN      ELMIN      SSTA
   SLOPE      XLOBL     XLCH      XLOBR     ITRIAL     IDC       ICONT     CORAR    TOPWID     ENDST


*SECNO 650.000
   650.00       .32   6710.52   6710.51       .00   6710.66       .14      2.69       .00   6725.00
    100.         0.      100.        0.        0.       33.        0.        0.        1.   6714.00
     .06        .00      3.00       .00      .000      .040      .000      .000   6710.20    195.66
 .030407       100.      100.      100.         3        12         0       .00    106.02    301.68


*SECNO 600.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   600.00       .26   6712.26   6712.26       .00   6712.38       .13      1.68       .00   6727.00
    100.         0.      100.        0.        0.       35.        0.        1.        1.   6712.00
     .06        .00      2.88      1.77      .000      .040      .040      .000   6712.00    134.23
 .037191        70.       50.       40.         0        12         0       .00    136.62    270.85


*SECNO 480.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.48

   480.00       .24   6715.24   6715.18       .00   6715.29       .05      2.90       .01   6715.00
    100.         0.      100.        0.        0.       53.        0.        1.        2.   6715.00
     .08        .05      1.87       .05      .040      .040      .040      .000   6715.00     72.33
 .016941       130.      120.      100.         4        16         0       .00    223.45    295.77


*SECNO 250.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   250.00       .11   6721.91   6721.91       .00   6721.96       .05      6.24       .00   6721.80
    100.         0.      100.        0.        0.       55.        0.        1.        4.   6721.80
     .12        .08      1.82       .08      .040      .040      .040      .000   6721.80     35.72
 .044848       310.      240.      160.         0        18         0       .00    497.57    533.29


*SECNO 200.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.73

   200.00       .14   6723.14   6723.11       .00   6723.17       .03      1.21       .00   6723.00
    100.         0.      100.        0.        0.       78.        0.        1.        4.   6723.00
     .13        .05      1.27       .80      .040      .040      .040      .000   6723.00     40.62
 .015023        60.       50.       50.         4        10         0       .00    532.50    573.12
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN        SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID       ENDST


*SECNO 165.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   3.08

    165.00       .29   6723.29   6723.10       .00   6723.30       .01       .13       .00   6723.00
      100.        0.      100.        0.        0.      154.        1.        1.        5.   6723.00
       .14       .39       .65       .41      .040      .040      .040      .000   6723.00     40.26
   .001588       35.       35.       35.         4        15         0       .00    534.90    575.16


CCHV=      .100 CEHV=      .300
*SECNO 150.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  24.14

    150.00      3.30   6723.30   6720.19       .00   6723.30       .00       .00       .00   6736.00
      100.        0.      100.        0.        0.     1153.        0.        1.        5.   6731.00
       .19       .00       .09       .00      .000      .040      .000      .000   6720.00     33.94
   .000003       15.       15.       15.         6        14         0       .00    684.45    718.39


*SECNO 100.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   4.81

    100.00     12.30   6723.30   6712.19       .00   6723.30       .00       .00       .00   6722.40
      100.        0.      100.        0.        1.     3214.        0.        4.        6.   6720.00
       .64       .01       .03       .00      .040      .040      .040      .000   6711.00     40.67
   .000000       50.       50.       50.         4        22         0       .00    844.63    885.30


*SECNO 50.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   2.19

     50.00     18.30   6723.30   6706.40       .00   6723.30       .00       .00       .00   6732.00
      100.        0.      100.        0.        0.     5239.        0.        9.        7.   6731.00
      1.36       .00       .02       .00      .000      .040      .000      .000   6705.00     22.66
   .000000       50.       50.       50.         2        20         0       .00    880.34    903.00
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T1        MIDDLE CREEK DAM
T2        AUXILIARY SPILLWAY - FINAL DESIGN - ALTERNATIVE C
T3        HKM ASSOCIATES - 4/88

J1  ICHECK     INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

       0          3         0         0        -1         0       0.5         0    6715.0

J2  NPROF      IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

      2                    -1                                       -1
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   SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
   Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
   TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


*PROF 2

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS



CCHV=     .100 CEHV=     .300
*SECNO 1140.000
3720 CRITICAL DEPTH ASSUMED
  1140.00      1.12  6701.62   6701.62   6715.00   6702.12       .51       .00       .00  6714.00
     500.        0.     467.       33.        0.       80.        9.        0.        0.  6700.50
      .00       .00     5.84      3.74      .000      .040      .040      .000   6700.50    55.53
  .022121        0.       0.        0.         0        22         0       .00     89.25   144.78


*SECNO 1050.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.36

  1050.00      1.88  6702.68   6701.94       .00   6702.86       .18       .71       .03  6717.00
     500.        0.     477.       23.        0.      138.       10.        0.        0.  6700.80
      .01       .00     3.46      2.23      .000      .040      .040      .000   6700.80    73.04
  .003985       90.      90.       90.         3         5         0       .00     87.73   160.77


*SECNO 972.000
   972.00      1.99  6702.99   6702.13       .00   6703.15       .16       .29       .00  6718.00
     500.        0.     500.        0.        0.      154.        0.        1.        0.  6715.00
      .01       .00     3.25       .00      .000      .040      .000      .000   6701.00    82.10
  .003432       78.      78.       78.         2        11         0       .00     83.87   165.96


*SECNO 850.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   850.00      1.19  6705.79   6705.79       .00   6706.35       .56       .87       .12  6723.00
     500.        0.     500.        0.        0.       83.        0.        1.        1.  6732.00
      .02       .00     6.01       .00      .000      .040      .000      .000   6704.60   115.16
  .022599      122.     122.      122.         0        11         0       .00     74.17   189.34


*SECNO 750.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
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     SECNO      DEPTH      CWSEL      CRIWS      WSELK     EG         HV         HL         OLOSS    BANK ELEV
     Q          QLOB       QCH        QROB       ALOB      ACH        AROB       VOL        TWA    LEFT/RIGHT
     TIME       VLOB       VCH        VROB       XNL       XNCH       XNR        WTN        ELMIN        SSTA
     SLOPE      XLOBL      XLCH       XLOBR      ITRIAL    IDC        ICONT      CORAR      TOPWID       ENDST


     750.00      1.07   6708.47    6708.47        .00   6708.97        .50       2.29        .01   6715.00
      500.         0.      497.         3.         0.       88.         1.         1.         1.    6707.70
       .02        .00      5.67       2.92       .000      .040       .040       .000    6707.40    195.82
   .023170      100.      100.       100.           0        11          0        .00      89.87    285.68


  *SECNO 650.000
  7185 MINIMUM SPECIFIC ENERGY
  3720 CRITICAL DEPTH ASSUMED
     650.00       .89   6711.09    6711.09        .00   6711.52        .43       2.39        .01   6725.00
      500.         0.      500.         0.         0.       95.         0.         1.         1.    6714.00
       .03        .00      5.25        .00       .000      .040       .000       .000    6710.20    193.28
   .024645      100.      100.       100.           0        15          0        .00     111.40    304.68


  *SECNO 600.000
  7185 MINIMUM SPECIFIC ENERGY
  3720 CRITICAL DEPTH ASSUMED
     600.00       .75   6712.75    6712.75        .00   6713.12        .37       1.26        .01   6727.00
      500.         0.      497.         3.         0.      102.         1.         1.         1.    6712.00
       .03        .00      4.88       3.00       .000      .040       .040       .000    6712.00    132.75
   .025694       70.       50.        40.           0        15          0        .00     139.74    272.50


  *SECNO 480.000
     480.00       .60   6715.60    6715.54        .00   6715.81        .21       2.68        .02   6715.00
      500.         1.      498.         1.         1.      134.         1.         2.         2.    6715.00
       .04       2.25      3.71       2.27       .040      .040       .040       .000    6715.00     71.31
   .019591      130.      120.       100.           3        15          0        .00     225.63    296.94


  *SECNO 250.000
  7185 MINIMUM SPECIFIC ENERGY
  3720 CRITICAL DEPTH ASSUMED
     250.00       .32   6722.12    6722.12        .00   6722.27        .15       6.00        .01   6721.80
      500.         0.      500.         0.         0.      158.         0.         3.         4.    6721.80
       .06       1.89      3.15       1.90       .040      .040       .040       .000    6721.80     35.19
   .033053      310.      240.       160.           0        11          0        .00     498.63    533.82


  *SECNO 200.000
     200.00       .37   6723.37    6723.30        .00   6723.47        .10       1.19        .01   6723.00
      500.         0.      498.         2.         0.      195.         1.         3.         4.    6723.00
       .07       1.54      2.56       1.61       .040      .040       .040       .000    6723.00     40.06
   .017979       60.       50.        50.           4         8          0        .00     536.21    576.27
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 SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
 Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA   LEFT/RIGHT
 TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
 SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST


*SECNO 165.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.53

   165.00       .65  6723.65  6723.30        .00  6723.68        .03        .20        .01  6723.00
    500.         0.     497.       3.         1.     340.         3.         3.         5.   6723.00
     .07        .88     1.46      .92       .040     .040       .040       .000  6723.00     39.36
  .002809       35.      35.      35.          3        8          0        .00   540.82    580.18


CCHV=      .100 CEHV=      .300
*SECNO 150.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  9.02

   150.00      3.68  6723.68  6720.53        .00  6723.68        .00        .00        .00  6736.00
    500.         0.     500.       0.         0.    1417.         0.         3.         5.   6731.00
     .09        .00      .35      .00       .000     .040       .000       .000  6720.00     32.91
  .000035       15.      15.      15.          5       11          0        .00   688.56    721.46


*SECNO 100.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  4.02

   100.00     12.68  6723.68  6713.27        .00  6723.68        .00        .00        .00  6722.40
    500.         0.     500.       0.         2.    3537.         1.         6.         6.   6720.00
     .19        .04      .14      .02       .040     .040       .040       .000  6711.00     39.68
  .000002       50.      50.      50.          4       14          0        .00   845.66    885.33


*SECNO 50.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.06

    50.00     18.68  6723.68  6707.68        .00  6723.68        .00        .00        .00  6732.00
    500.         0.     500.       0.         0.    5577.         0.        11.         7.   6731.00
     .34        .00      .09      .00       .000     .040       .000       .000  6705.00     21.66
  .000001       50.      50.      50.          2       21          0        .00   881.69    903.35
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T1        MIDDLE CREEK DAM
T2        AUXILIARY SPILLWAY - FINAL DESIGN - ALTERNATIVE C
T3        HKM ASSOCIATES - 4/88

J1   ICHECK     INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

        0         4         0         0        -1         0       0.5         0    6715.0

J2   NPROF      IFLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW       CHNIM     ITRACE

       3                   -1                                       -1
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   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN       SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


*PROF 3

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS



CCHV=     .100 CEHV=     .300
*SECNO 1140.000
3720 CRITICAL DEPTH ASSUMED
  1140.00     1.73  6702.23  6702.23  6715.00  6702.98      .75      .00      .00  6714.00
   1000.       0.     902.      98.       0.     126.      21.       0.       0.    6700.50
      .00      .00     7.15     4.62     .000     .040     .040     .000  6700.50    53.60
  .018758      0.       0.       0.         0       16        0      .00    99.93   153.54


*SECNO 1050.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.98

  1050.00     2.65  6703.45  6702.58      .00  6703.79      .33      .76      .04  6717.00
   1000.       0.     938.      62.       0.     199.      20.       0.       0.    6700.80
      .01      .00     4.72     3.08     .000     .040     .040     .000  6700.80    70.17
  .004808     90.      90.      90.         3        8        0      .00    95.03   165.20


*SECNO 972.000
   972.00     2.83  6703.83  6702.78      .00  6704.14      .30      .35      .00  6718.00
   1000.       0.    1000.       0.       0.     227.       0.       1.       0.    6715.00
      .01      .00     4.41      .00     .000     .040     .000     .000  6701.00    79.18
  .004112     78.      78.      78.         2       14        0      .00    89.32   168.49


*SECNO 850.000

1645 INT SEC ADDED BY RAISING SEC    850.00,  -1.800 FT AND MULTIPLYING BY   1.342

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
     1.01     1.53  6704.33  6704.33      .00  6705.06      .72      .48      .13  6721.20
   1000.       0.    1000.       0.       0.     146.       0.       1.       1.    6730.20
      .01      .00     6.83      .00     .000     .040     .000     .000  6702.80   152.66
  .021142     61.      61.      61.         0       11        0      .00   102.72   255.38
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN        SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID       ENDST


1645 INT SEC ADDED BY RAISING SEC          1.01,    1.800 FT AND MULTIPLYING BY        .745

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    850.00      1.86   6706.46   6706.46       .00   6707.32       .86      1.25       .04   6723.00
    1000.        0.      1000.        0.        0.     135.         0.        1.        1.    6732.00
       .02       .00      7.43       .00      .000      .040      .000      .000   6704.60    112.43
   .019793       61.       61.       61.         0        11         0       .00     78.80    191.22


*SECNO 750.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    750.00      1.67   6709.07   6709.07       .00   6709.82       .75      1.99       .01   6715.00
    1000.        0.       987.       13.        0.     141.         3.        2.        1.    6707.70
       .02       .00      6.99      3.99      .000      .040      .040      .000   6707.40    190.71
   .020083      100.      100.      100.         0        11         0       .00     97.05    287.75


*SECNO 650.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    650.00      1.39   6711.59   6711.59       .00   6712.26       .66      2.08       .01   6725.00
    1000.        0.      1000.        0.        0.     153.         0.        2.        1.    6714.00
       .02       .00      6.54       .00      .000      .040      .000      .000   6710.20    191.16
   .021597      100.      100.      100.         0        15         0       .00    116.18    307.34


*SECNO 600.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    600.00      1.19   6713.19   6713.19       .00   6713.76       .58      1.09       .01   6727.00
    1000.        0.       991.        9.        0.     162.         2.        2.        1.    6712.00
       .03       .00      6.11      3.78      .000      .040      .040      .000   6712.00    131.44
   .021989       70.       50.       40.         0        11         0       .00    142.51    273.95


*SECNO 480.000
    480.00       .91   6715.91   6715.85       .00   6716.28       .37      2.50       .02   6715.00
    1000.        3.       993.        4.        1.     202.         1.        3.        2.    6715.00
       .03      2.97      4.91      3.00      .040      .040      .040      .000   6715.00     70.45
   .019788      130.      120.      100.         3        15         0       .00    227.47    297.92
   SECNO       DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q           QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME        VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE       XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*SECNO 250.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   250.00         .50  6722.30  6722.30        .00  6722.55        .25       5.78        .01  6721.80
   1000.           1.     998.       1.         0.     247.         0.         4.         4.   6721.80
     .05         2.42     4.04     2.43       .040     .040       .040       .000   6721.80    34.74
  .029962        310.     240.     160.          0       11          0        .00    499.55   534.28


*SECNO 200.000
   200.00         .55  6723.55  6723.48        .00  6723.73        .18       1.17        .01  6723.00
   1000.           1.     995.       5.         0.     291.         2.         4.         4.   6723.00
     .05         2.06     3.42     2.15       .040     .040       .040       .000   6723.00    39.59
  .018908         60.      50.      50.          3        8          0        .00    539.26   578.86


*SECNO 165.000

3302 WARNING:   CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,   KRATIO =   2.35

   165.00         .92  6723.92  6723.48        .00  6723.98        .06        .24        .01  6723.00
   1000.           1.     991.       8.         1.     484.         6.         4.         5.   6723.00
     .06         1.23     2.05     1.29       .040     .040       .040       .000   6723.00    38.66
  .003424         35.      35.      35.          3       15          0        .00    545.44   584.09


CCHV=      .100 CEHV=      .300
*SECNO 150.000

3302 WARNING:   CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,   KRATIO =   6.23

   150.00        3.98  6723.98  6720.82        .00  6723.99        .01        .00        .01  6736.00
   1000.           0.    1000.       0.         0.    1624.         0.         5.         5.   6731.00
     .06          .00      .62      .00       .000     .040       .000       .000   6720.00    32.11
  .000088         15.      15.      15.          5       11          0        .00    691.76   723.87


*SECNO 100.000

3302 WARNING:   CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,   KRATIO =   3.61

   100.00       12.99  6723.99  6714.00        .00  6723.99        .00        .00        .00  6722.40
   1000.           0.    1000.       0.         3.    3795.         1.         8.         6.   6720.00
     .12          .08      .26      .03       .040     .040       .040       .000   6711.00    38.88
  .000007         50.      50.      50.          4       19          0        .00    846.48   885.36
```

```
   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 50.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.99

    50.00     18.99   6723.99   6708.53       .00   6723.99       .00       .00       .00   6732.00
    1000.        0.     1000.        0.        0.     5849.        0.       13.        7.   6731.00
      .20       .00       .17       .00      .000      .040      .000      .000   6705.00     20.85
  .000002       50.       50.       50.         2        14         0       .00    882.77    903.63
```

```
T1       MIDDLE CREEK DAM
T2       AUXILIARY SPILLWAY - FINAL DESIGN - ALTERNATIVE C
T3       HKM ASSOCIATES - 4/88

J1  ICHECK    INQ       NINV      IDIR      STRT      METRIC    HVINS     Q         WSEL      FQ

       0         5         0         0        -1         0       0.5         0    6715.0
MULTIPLE PROFILE RUN WITH INTERPOLATED CROSS SECTIONS

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN       ALLDC     IBW       CHNIM      ITRACE

      4                  -1                                      -1
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```
 SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
 Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
 TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
 SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*PROF 4

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS


CCHV=      .100 CEHV=      .300
*SECNO 1140.000
3720 CRITICAL DEPTH ASSUMED
  1140.00       4.53  6705.03  6705.03  6715.00  6706.74       1.71       .00        .00  6714.00
   5000.         0.     3909.     1091.       0.      349.      145.        0.         0.   6700.50
     .00        .00     11.19      7.50     .000      .040      .040      .000   6700.50     44.90
  .013741        0.        0.        0.        0        16         0       .00    148.25    193.14


*SECNO 1050.000
  1050.00       5.49  6706.29  6705.65      .00  6707.75       1.46       .98        .03  6717.00
   5000.         0.     4412.      588.       0.      441.       87.        1.         0.   6700.80
     .00        .00     10.01      6.80     .000      .040      .040      .000   6700.80     59.65
  .008878       90.       90.       90.        3         8         0       .00    121.84    181.48


*SECNO 972.000
   972.00       6.13  6707.13  6705.94      .00  6708.38       1.25       .61        .02  6718.00
   5000.         0.     5000.        0.       0.      557.        0.        2.         0.   6715.00
     .01        .00      8.98       .00     .000      .040      .000      .000   6701.00     67.72
  .006919       78.       78.       78.        3        11         0       .00    110.68    178.40


*SECNO 850.000

1645 INT SEC ADDED BY RAISING SEC     850.00,  -1.800 FT AND MULTIPLYING BY    1.154


3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
     1.01       4.67  6707.47  6707.47      .00  6709.45       1.98       .60        .22  6721.20
   5000.         0.     5000.        0.       0.      443.        0.        3.         1.   6730.20
     .01        .00     11.29       .00     .000      .040      .000      .000   6702.80    116.49
  .015210       61.       61.       61.        0        15         0       .00    113.32    229.81
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   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


1645 INT SEC ADDED BY RAISING SEC      1.01,   1.800 FT AND MULTIPLYING BY    .867

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   850.00     5.11  6709.71  6709.71      .00  6711.84     2.13      .92      .05  6723.00
    5000.       0.    5000.       0.       0.     427.       0.       3.       1.   6732.00
      .01      .00    11.71      .00     .000     .040     .000     .000  6704.60    99.18
  .014869      61.      61.      61.        0        8        0      .00   101.17   200.35


*SECNO 750.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   750.00     4.51  6711.91  6711.91      .00  6713.71     1.81     1.49      .03  6715.00
    5000.       0.    4778.     222.       0.     437.      31.       4.       1.   6707.70
      .01      .00    10.93     7.24     .000     .040     .040     .000  6707.40   166.46
  .014886     100.     100.     100.        0       11        0      .00   131.12   297.58


*SECNO 650.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   650.00     3.91  6714.11  6714.11      .00  6715.83     1.72     1.53      .01  6725.00
    5000.       0.    5000.       0.       0.     475.       0.       5.       1.   6714.00
      .01      .00    10.53      .05     .000     .040     .040     .000  6710.20   180.62
  .015793     100.     100.     100.        0       11        0      .00   139.67   320.29


*SECNO 600.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   600.00     3.40  6715.40  6715.40      .00  6717.00     1.60      .78      .01  6727.00
    5000.       0.    4876.     124.       0.     477.      19.       6.       2.   6712.00
      .01      .00    10.23     6.43     .000     .040     .040     .000  6712.00   124.80
  .015632      70.      50.      40.        0       11        0      .00   156.54   281.34


*SECNO 480.000

1645 INT SEC ADDED BY RAISING SEC    480.00,  -1.500 FT AND MULTIPLYING BY    .816
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN      SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID    ENDST


3301 HV CHANGED MORE THAN HVINS

      1.01      3.27   6716.77   6716.33       .00   6717.80      1.03       .74       .06   6713.50
     5000.       60.     4871.       69.       12.      592.       14.        7.        2.   6713.50
       .02      4.89      8.23      4.95      .040      .040      .040      .000   6713.50     52.07
   .010104       65.       60.       50.         2        15         0       .00    197.08    249.15


1645 INT SEC ADDED BY RAISING SEC      1.01,    1.500 FT AND MULTIPLYING BY   1.226

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    480.00      2.47   6717.47   6717.47       .00   6718.69      1.22       .78       .06   6715.00
     5000.       46.     4900.       54.        9.      549.       10.        8.        2.   6715.00
       .02      5.40      8.93      5.45      .040      .040      .040      .000   6715.00     66.08
   .017279       65.       60.       50.         0        15         0       .00    236.86    302.94

*SECNO 250.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    250.00      1.46   6723.26   6723.26       .00   6723.99       .73      4.51       .05   6721.80
     5000.       11.     4978.       11.        3.      726.        3.       11.        4.   6721.80
       .03      4.12      6.86      4.12      .040      .040      .040      .000   6721.80     32.30
   .020540      310.      240.      160.         0        11         0       .00    504.48    536.77

*SECNO 200.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
    200.00      1.40   6724.40   6724.40       .00   6725.08       .68      1.03       .00   6723.00
     5000.       10.     4931.       59.        2.      740.       14.       12.        5.   6723.00
       .03      4.00      6.67      4.19      .040      .040      .040      .000   6723.00     37.42
   .020631       60.       50.       50.         0         8         0       .00    553.59    591.01

*SECNO 165.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.06

    165.00      2.14   6725.14   6724.39       .00   6725.43       .28       .31       .04   6723.00
     5000.       15.     4895.       89.        6.     1136.       33.       13.        5.   6723.00
       .03      2.59      4.31      2.71      .040      .040      .040      .000   6723.00     35.51
   .004864       35.       35.       35.         3         5         0       .00    566.23    601.73
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


CCHV=      .100 CEHV=       .300
*SECNO 150.000

3302 WARNING:   CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  3.25

    150.00      5.41   6725.41   6722.17       .00   6725.47       .06       .02       .02   6736.00
     5000.        0.     5000.        0.        0.     2622.        0.       13.        5.    6731.00
       .03       .00      1.91       .00      .000      .040      .000      .000   6720.00     28.29
   .000459       15.       15.       15.         4         5         0       .00    707.00    735.29


*SECNO 100.000

3302 WARNING:   CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.64

    100.00     14.46   6725.46   6716.70       .00   6725.48       .02       .01       .00   6722.40
     5000.        5.     4995.        0.       12.     5036.        1.       18.        6.    6720.00
       .05       .38       .99       .12      .040      .040      .040      .000   6711.00     35.06
   .000066       50.       50.       50.         4         8         0       .00    850.43    885.50


*SECNO 50.000

3302 WARNING:   CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.73

     50.00     20.47   6725.47   6711.73       .00   6725.48       .01       .00       .00   6732.00
     5000.        0.     5000.        0.        0.     7162.        0.       25.        7.    6731.00
       .07       .00       .70       .00      .000      .040      .000      .000   6705.00     16.99
   .000022       50.       50.       50.         3        14         0       .00    887.98    904.98
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T1       MIDDLE CREEK DAM
T2       AUXILIARY SPILLWAY - FINAL DESIGN - ALTERNATIVE C
T3       HKM ASSOCIATES - 4/88

J1   ICHECK     INQ       NINV      IDIR      STRT      METRIC    HVINS     Q          WSEL      FQ

        0         6         0         0        -1         0       0.5         0    6715.0
MULTIPLE PROFILE RUN WITH INTERPOLATED CROSS SECTIONS

J2   NPROF      IPLOT     PRFVS     XSECV     XSECH     FN        ALLDC     IBW        CHNIM     ITRACE

        5                  -1                                      -1
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID     ENDST


*PROF 5

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS



CCHV=     .100 CEHV=     .300
*SECNO 1140.000
3720 CRITICAL DEPTH ASSUMED
   1140.00      6.66   6707.16   6707.16   6715.00   6709.50      2.34       .00       .00   6714.00
    10000.        0.     7128.     2872.        0.      535.      314.        0.        0.   6700.50
       .00       .00     13.31      9.15      .000      .040      .040      .000   6700.50     38.27
   .012231        0.        0.        0.         0        13         0       .00    184.97    223.25


*SECNO 1050.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   1050.00      7.32   6708.12   6708.12       .00   6710.90      2.78      1.10       .13   6717.00
    10000.        0.     8517.     1483.        0.      611.      153.        2.        0.   6700.80
       .00       .00     13.93      9.67      .000      .040      .040      .000   6700.80     52.90
   .012264       90.       90.       90.         0         8         0       .00    139.01    191.91


*SECNO 972.000

1645 INT SEC ADDED BY RAISING SEC    972.00,    -.100 FT AND MULTIPLYING BY     .922

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
      1.01      7.88   6708.78   6708.78       .00   6711.94      3.16       .50       .11   6717.90
    10000.        0.    10000.        0.        0.      701.        0.        2.        0.   6714.90
       .00       .00     14.26       .00      .000      .040      .000      .000   6700.90     56.80
   .013231       39.       39.       39.         0         8         0       .00    112.45    169.25


1645 INT SEC ADDED BY RAISING SEC      1.01,     .100 FT AND MULTIPLYING BY   1.085


3301 HV CHANGED MORE THAN HVINS
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  SECNO      DEPTH      CWSEL      CRIWS      WSELK     EG         HV         HL         OLOSS   BANK ELEV
  Q          QLOB       QCH        QROB       ALOB      ACH        AROB       VOL        TWA    LEFT/RIGHT
  TIME       VLOB       VCH        VROB       XNL       XNCH       XNR        WTN        ELMIN        SSTA
  SLOPE      XLOBL      XLCH       XLOBR      ITRIAL    IDC        ICONT      CORAR      TOPWID       ENDST


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.66

   972.00      9.91  6710.91  6708.54       .00  6712.40      1.49       .29       .17  6718.00
   10000.        0.   10000.       0.        0.     1022.       0.        3.        1.   6715.00
      .00       .00     9.78      .00      .000     .040      .000      .000  6701.00     54.59
  .004811       39.      39.      39.         5        8         0       .00   135.16    189.75


*SECNO 850.000

1645 INT SEC ADDED BY RAISING SEC     850.00,  -2.700 FT AND MULTIPLYING BY   1.322


3301 HV CHANGED MORE THAN HVINS

     1.01      9.72  6711.62  6708.45       .00  6712.57       .95       .12       .05  6720.30
   10000.        0.   10000.       0.        0.     1279.       0.        4.        1.   6729.30
      .00       .00     7.82      .00      .000     .040      .000      .000  6701.90    106.27
  .003191       31.      31.      31.         2       14         0       .00   175.85    282.12



1645 INT SEC ADDED BY RAISING SEC       1.01,    .900 FT AND MULTIPLYING BY    .919


3301 HV CHANGED MORE THAN HVINS

     1.02      8.50  6711.30  6709.68       .00  6712.90      1.60       .13       .20  6721.20
   10000.        0.   10000.       0.        0.      984.       0.        5.        1.   6730.20
      .01       .00    10.16      .00      .000     .040      .000      .000  6702.80    103.70
  .006277       31.      31.      31.         3       19         0       .00   151.31    255.01



1645 INT SEC ADDED BY RAISING SEC       1.02,    .900 FT AND MULTIPLYING BY    .912


3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
     1.03      7.29  6710.99  6710.99       .00  6713.86      2.87       .27       .38  6722.10
   10000.        0.   10000.       0.        0.      735.       0.        5.        1.   6731.10
      .01       .00    13.60      .00      .000     .040      .000      .000  6703.70    100.00
  .013390       31.      31.      31.         0       11         0       .00   128.67    228.67
  SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
  Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
  TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
  SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


1645 INT SEC ADDED BY RAISING SEC       1.03,     .900 FT AND MULTIPLYING BY     .903

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   850.00       7.72  6712.32  6712.32        .00  6715.36       3.04        .41        .05  6723.00
   10000.         0.   10000.        0.        0.     715.         0.         6.         1.   6732.00
      .01        .00    13.99       .00      .000     .040       .000       .000   6704.60     88.53
  .013341        31.      31.       31.         0        8          0        .00    119.17    207.70


*SECNO 750.000

1645 INT SEC ADDED BY RAISING SEC     750.00,  -1.400 FT AND MULTIPLYING BY     .918


3301 HV CHANGED MORE THAN HVINS

     1.01       8.18  6714.18  6713.09        .00  6715.97       1.78        .48        .13  6713.60
   10000.         1.    9243.      755.        1.     845.        99.         7.         1.   6706.30
      .01       1.37    10.93      7.65      .040     .040       .040       .000   6706.00    124.74
  .007260        50.      50.       50.         3       11          0        .00    159.98    284.72


1645 INT SEC ADDED BY RAISING SEC       1.01,    1.400 FT AND MULTIPLYING BY    1.090


3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   750.00       6.73  6714.13  6714.13        .00  6716.68       2.54        .48        .23  6715.00
   10000.         0.    9346.      654.        0.     718.        72.         8.         1.   6707.70
      .01        .00    13.01      9.11      .000     .040       .040       .000   6707.40    147.40
  .013343        50.      50.       50.         0       15          0        .00    157.91    305.31


*SECNO 650.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   650.00       5.98  6716.18  6716.18        .00  6718.76       2.58       1.34        .01  6725.00
   10000.         0.    9972.       28.        0.     772.         6.        10.         2.   6714.00
      .01        .00    12.92      4.37      .000     .040       .040       .000   6710.20    171.96
  .013499       100.     100.      100.         0       11          0        .00    153.89    325.85
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK     EG         HV         HL         OLOSS   BANK ELEV
   Q          QLOB       QCH        QROB       ALOB      ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL       XNCH       XNR        WTN        ELMIN       SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL    IDC        ICONT      CORAR      TOPWID      ENDST


*SECNO 600.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   600.00       5.32  6717.32  6717.32       .00  6719.75       2.43        .67        .02  6727.00
   10000.         0.    9620.     380.        0.     760.        47.        10.         2.   6712.00
     .01         .00    12.65     8.06      .000     .040       .040       .000   6712.00    119.05
  .013540        70.      50.      40.         0       11          0        .00    168.68    287.72


*SECNO 480.000

1645 INT SEC ADDED BY RAISING SEC    480.00,  -2.000 FT AND MULTIPLYING BY    .763


3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.42

     1.01       5.77  6718.77  6717.67       .00  6720.21       1.44        .37        .10  6713.00
   10000.       205.    9557.     238.       36.     976.        41.        11.         2.   6713.00
     .01        5.77     9.79     5.86      .040     .040       .040       .000   6713.00     43.36
  .006712        43.      40.      33.         3       11          0        .00    195.75    239.11



1645 INT SEC ADDED BY RAISING SEC       1.01,   1.000 FT AND MULTIPLYING BY   1.156

     1.02       5.11  6719.11  6718.24       .00  6720.50       1.39        .28        .01  6714.00
   10000.       185.    9599.     215.       32.    1001.        37.        12.         2.   6714.00
     .01        5.74     9.59     5.81      .040     .040       .040       .000   6714.00     51.71
  .007557        43.      40.      33.         3       15          0        .00    222.76    274.47



1645 INT SEC ADDED BY RAISING SEC       1.02,   1.000 FT AND MULTIPLYING BY   1.135

   480.00       4.38  6719.38  6718.91       .00  6720.88       1.50        .35        .03  6715.00
   10000.       161.    9652.     187.       27.     972.        31.        13.         2.   6715.00
     .02        6.01     9.93     6.07      .040     .040       .040       .000   6715.00     60.74
  .009985        43.      40.      33.         3       15          0        .00    248.31    309.05
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*SECNO 250.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   250.00       2.31  6724.11  6724.11        .00  6725.27       1.16       3.13        .03  6721.80
   10000.        35.    9929.       36.        7.    1147.         7.        19.         5.   6721.80
      .02       5.19     8.65      5.20      .040      .040      .040       .000  6721.80     30.15
  .017783       310.     240.      160.         0        11         0        .00   508.81    538.96


*SECNO 200.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   200.00       2.21  6725.21  6725.21        .00  6726.28       1.07        .89        .01  6723.00
   10000.        31.    9785.      183.        6.    1169.        35.        21.         5.   6723.00
      .03       5.03     8.37      5.27      .040      .040      .040       .000  6723.00     35.35
  .017697        60.      50.       50.         0         8         0        .00   567.26    602.61


*SECNO 165.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.81

   165.00       3.13  6726.13  6725.20        .00  6726.65        .52        .31        .06  6723.00
   10000.        44.    9698.      258.       13.    1657.        70.        22.         6.   6723.00
      .03       3.52     5.85      3.68      .040      .040      .040       .000  6723.00     32.99
  .005426        35.      35.       35.         4         5         0        .00   582.83    615.82


CCHV=     .100 CEHV=     .300
*SECNO 150.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.69

   150.00       6.58  6726.58  6723.48        .00  6726.71        .13        .02        .04  6736.00
   10000.         0.   10000.        0.        0.    3458.         0.        23.         6.   6731.00
      .03        .00     2.89       .00      .000      .040      .000       .000  6720.00     25.16
  .000749        15.      15.       15.         4         8         0        .00   719.50    744.66
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*SECNO 100.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.31

    100.00     15.69   6726.69   6718.71       .00   6726.73       .04       .01       .01   6722.40
    10000.       17.     9983.        0.       24.     6071.        2.       28.        7.    6720.00
       .04       .70      1.64       .20      .040      .040      .040      .000   6711.00     31.88
   .000141       50.       50.       50.         4        11         0       .00    853.73    885.61

*SECNO 50.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.60

     50.00     21.72   6726.72   6714.03       .00   6726.74       .02       .00       .00   6732.00
    10000.        0.    10000.        0.        0.     8269.        0.       36.        8.    6731.00
       .05       .00      1.21       .00      .000      .040      .000      .000   6705.00     13.75
   .000055       50.       50.       50.         3        11         0       .00    892.35    906.11
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T1        MIDDLE CREEK DAM
T2        AUXILIARY SPILLWAY - FINAL DESIGN - ALTERNATIVE C
T3        HKM ASSOCIATES - 4/88

J1   ICHECK      INQ        NINV       IDIR       STRT       METRIC     HVINS      Q          WSEL       FQ

          0          7          0          0         -1          0        0.5          0     6715.0
MULTIPLE PROFILE RUN WITH INTERPOLATED CROSS SECTIONS

J2   NPROF       IPLOT      PRFVS      XSECV      XSECH      FN         ALLDC      IBW        CHNIM      ITRACE

          6                    -1                                         -1
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  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST

*PROF 6

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS


CCHV=      .100 CEHV=      .300
*SECNO 1140.000
3720 CRITICAL DEPTH ASSUMED
  1140.00      8.29  6708.79  6708.79  6715.00  6711.54      2.76       .00       .00  6714.00
   15000.        0.   10039.    4961.       0.     687.      486.        0.        0.  6700.50
     .00       .00    14.62    10.21     .000     .040      .040      .000  6700.50     33.22
  .011396        0.       0.       0.        0       10         0       .00   213.01    246.23


*SECNO 1050.000

1645 INT SEC ADDED BY RAISING SEC   1050.00,   -.150 FT AND MULTIPLYING BY    .929


3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
     1.01      9.61  6710.26  6710.26      .00  6713.72      3.46       .51       .21  6716.85
   15000.        0.   12266.    2734.       0.     784.      246.        1.        0.  6700.65
     .00       .00    15.65    11.12     .000     .040      .040      .000  6700.65     41.23
  .011306       45.      45.      45.        0        8         0       .00   149.22    190.45


1645 INT SEC ADDED BY RAISING SEC      1.01,    .150 FT AND MULTIPLYING BY   1.077


3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.58

  1050.00     11.69  6712.49  6710.03      .00  6714.20      1.71       .31       .17  6717.00
   15000.        0.   11859.    3141.       0.    1072.      392.        2.        0.  6700.80
     .00       .00    11.07     8.02     .000     .040      .040      .000  6700.80     36.70
  .004518       45.      45.      45.        5        8         0       .00   180.28    216.98
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 SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
 Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
 TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN         SSTA
 SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*SECNO 972.000

1645 INT SEC ADDED BY RAISING SEC    972.00,   -.100 FT AND MULTIPLYING BY    .921


3301 HV CHANGED MORE THAN HVINS

     1.01      10.87    6711.77    6710.92        .00    6714.86       3.09        .24        .41   6717.90
   15000.         0.     15000.         0.         0.      1063.         0.         4.         0.   6714.90
      .00        .00      14.11        .00       .000       .040       .000       .000    6700.90     47.24
  .009099        39.        39.        39.          3         11          0        .00     130.18    177.42



1645 INT SEC ADDED BY RAISING SEC       1.01,    .100 FT AND MULTIPLYING BY   1.086


3301 HV CHANGED MORE THAN HVINS

   972.00      12.38    6713.38    6710.54        .00    6715.23       1.85        .25        .12   6718.00
   15000.         0.     15000.         0.         0.      1375.         0.         5.         1.   6715.00
      .00        .00      10.91        .00       .000       .040       .000       .000    6701.00     46.03
  .004688        39.        39.        39.          4         11          0        .00     151.12    197.15

*SECNO 850.000

1645 INT SEC ADDED BY RAISING SEC    850.00,  -2.700 FT AND MULTIPLYING BY   1.312


3301 HV CHANGED MORE THAN HVINS

     1.01      12.39    6714.29    6710.26        .00    6715.41       1.12        .11        .07   6720.30
   15000.         0.     15000.         0.         0.      1765.         0.         6.         1.   6729.30
      .00        .00       8.50        .00       .000       .040       .000       .000    6701.90     91.20
  .002894        31.        31.        31.          0         14          0        .00     198.44    289.64



1645 INT SEC ADDED BY RAISING SEC       1.01,    .900 FT AND MULTIPLYING BY    .921
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 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


3301 HV CHANGED MORE THAN HVINS

     1.02     11.16  6713.96  6711.55       .00  6715.72      1.76       .12       .19  6721.20
   15000.        0.   15000.        0.        0.    1408.        0.        7.        1.   6730.20
      .01       .00    10.66       .00      .000     .040      .000      .000   6702.80     90.00
  .005116       31.      31.       31.         3       19         0       .00    172.54    262.54


1645 INT SEC ADDED BY RAISING SEC      1.02,     .900 FT AND MULTIPLYING BY     .914


3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =    .65

     1.03      9.33  6713.03  6712.91       .00  6716.45      3.42       .23       .50  6722.10
   15000.        0.   15000.        0.        0.    1011.        0.        8.        1.   6731.10
      .01       .00    14.83       .00      .000     .040      .000      .000   6703.70     90.47
  .012111       31.      31.       31.         4       15         0       .00    143.81    234.28


1645 INT SEC ADDED BY RAISING SEC      1.03,     .900 FT AND MULTIPLYING BY     .906

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   850.00      9.75  6714.35  6714.35       .00  6718.06      3.71       .38       .09  6723.00
   15000.        0.   15000.        0.        0.     971.        0.        8.        1.   6732.00
      .01       .00    15.45       .00      .000     .040      .000      .000   6704.60     80.25
  .012579       31.      31.       31.         0        8         0       .00    133.15    213.40

*SECNO 750.000

1645 INT SEC ADDED BY RAISING SEC    750.00,  -1.867 FT AND MULTIPLYING BY     .898


3301 HV CHANGED MORE THAN HVINS
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   SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN        SSTA
   SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID       ENDST


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.65

     1.01     11.12   6716.65   6714.41       .00   6718.48      1.83       .24       .19   6713.13
   15000.      141.    13489.     1370.       39.     1204.      182.        9.        1.    6705.83
      .01      3.65     11.20      7.53      .040      .040      .040      .000   6705.53    103.64
  .004620       33.       33.       33.         4        11         0       .00    184.16    287.80


1645 INT SEC ADDED BY RAISING SEC       1.01,     .933 FT AND MULTIPLYING BY   1.057

     1.02     10.18   6716.65   6715.08       .00   6718.73      2.08       .17       .07   6714.07
   15000.       75.    13625.     1300.       22.     1147.      161.       10.        1.    6706.77
      .01      3.38     11.88      8.09      .040      .040      .040      .000   6706.47    115.70
  .005974       33.       33.       33.         3        15         0       .00    185.39    301.09


1645 INT SEC ADDED BY RAISING SEC       1.02,     .933 FT AND MULTIPLYING BY   1.054

   750.00      9.22   6716.63   6715.78       .00   6719.07      2.45       .23       .11   6715.00
   15000.       27.    13749.     1224.        9.     1071.      138.       11.        1.    6707.70
      .01      2.90     12.84      8.87      .040      .040      .040      .000   6707.40    128.66
  .008195       33.       33.       33.         3        15         0       .00    185.28    313.93

*SECNO 650.000

1645 INT SEC ADDED BY RAISING SEC     650.00,  -1.400 FT AND MULTIPLYING BY   1.022

     1.01      8.07   6716.87   6716.35       .00   6719.61      2.74       .45       .09   6723.60
   15000.        0.    14854.      146.        0.     1114.       25.       13.        2.    6712.60
      .01       .00     13.33      5.85      .000      .040      .040      .000   6708.80    166.73
  .009804       50.       50.       50.         3        15         0       .00    171.89    338.62


1645 INT SEC ADDED BY RAISING SEC       1.01,    1.400 FT AND MULTIPLYING BY    .979

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   650.00      7.69   6717.89   6717.89       .00   6721.10      3.21       .55       .14   6725.00
   15000.        0.    14876.      124.        0.     1031.       20.       14.        2.    6714.00
      .01       .00     14.42      6.12      .000      .040      .040      .000   6710.20    164.80
  .012198       50.       50.       50.         0         8         0       .00    165.65    330.45
  SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
  Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
  TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
  SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID      ENDST


*SECNO 600.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   600.00      6.88  6718.88  6718.88        .00  6721.96       3.08        .61        .01  6727.00
  15000.         0.   14275.      725.        0.      999.       79.        15.         2.   6712.00
     .01        .00    14.29      9.20      .000      .040      .040      .000   6712.00    114.37
 .012511        70.      50.       40.         0        11         0       .00    178.55    292.92


*SECNO 480.000

1645 INT SEC ADDED BY RAISING SEC    480.00,  -2.250 FT AND MULTIPLYING BY    .741


3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE.  KRATIO =  1.46

    1.01       7.73  6720.48  6718.96        .00  6722.33       1.84        .25        .12  6712.75
  15000.       405.   14124.      471.       62.     1272.       71.        16.         2.   6712.75
     .01       6.52    11.10      6.63      .040      .040      .040      .000   6712.75     38.05
 .005843        33.      30.       25.         4        11         0       .00    198.92    236.97


1645 INT SEC ADDED BY RAISING SEC      1.01,    .750 FT AND MULTIPLYING BY   1.117

    1.02       7.40  6720.90  6719.28        .00  6722.52       1.62        .17        .02  6713.50
  15000.       393.   14150.      457.       63.     1359.       73.        17.         2.   6713.50
     .01       6.19    10.41      6.27      .040      .040      .040      .000   6713.50     43.24
 .005441        33.      30.       25.         2        15         0       .00    220.46    263.71


1645 INT SEC ADDED BY RAISING SEC      1.02,    .750 FT AND MULTIPLYING BY   1.104

    1.03       6.89  6721.14  6719.67        .00  6722.69       1.55        .17        .01  6714.25
  15000.       371.   14199.      430.       61.     1399.       70.        18.         3.   6714.25
     .01       6.10    10.15      6.17      .040      .040      .040      .000   6714.25     49.06
 .005689        33.      30.       25.         3        15         0       .00    240.69    289.75
 SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
 Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
 TIME       VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
 SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


1645 INT SEC ADDED BY RAISING SEC       1.03,     .750 FT AND MULTIPLYING BY    1.095

   480.00      6.32  6721.32  6720.10       .00  6722.87      1.56       .18       .00  6715.00
   15000.      344.   14258.     398.       56.    1402.       64.       19.        3.   6715.00
      .02      6.15    10.17     6.21      .040     .040      .040      .000   6715.00    55.31
  .006416       33.      30.      25.         3       15         0       .00    259.96   315.28


*SECNO 250.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   250.00      3.03  6724.83  6724.83       .00  6726.33      1.50      2.31       .01  6721.80
   15000.       69.   14861.      70.       12.    1508.       12.       27.        5.   6721.80
      .02      5.92     9.86     5.93      .040     .040      .040      .000   6721.80    28.31
  .016035      310.     240.     160.         0       11         0       .00    512.52   540.83


*SECNO 200.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   200.00      2.88  6725.88  6725.88       .00  6727.27      1.39       .80       .01  6723.00
   15000.       61.   14582.     357.       11.    1527.       60.       29.        5.   6723.00
      .02      5.74     9.55     6.00      .040     .040      .040      .000   6723.00    33.62
  .016102       60.      50.      50.         0        8         0       .00    578.69   612.31


*SECNO 165.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   1.68

   165.00      3.92  6726.92  6725.87       .00  6727.65       .74       .31       .07  6723.00
   15000.       82.   14438.     480.       20.    2073.      110.       31.        6.   6723.00
      .03      4.18     6.96     4.38      .040     .040      .040      .000   6723.00    30.98
  .005699       35.      35.      35.         4        5         0       .00    596.10   627.07


CCHV=      .100 CEHV=      .300
*SECNO 150.000
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  SECNO     DEPTH     CWSEL     CRIWS     WSELK    EG        HV        HL        OLOSS    BANK ELEV
  Q         QLOB      QCH       QROB      ALOB     ACH       AROB      VOL       TWA    LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL      XNCH      XNR       WTN       ELMIN       SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL   IDC       ICONT     CORAR     TOPWID      ENDST


3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.46

   150.00      7.53   6727.53   6724.05       .00   6727.73       .20       .03       .05  6736.00
   15000.        0.    15000.        0.        0.     4145.        0.       32.        6.   6731.00
      .03       .00      3.62       .00      .000      .040      .000      .000   6720.00     22.63
  .000939       15.       15.       15.         4         8         0       .00    729.61    752.24

*SECNO 100.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.14

   100.00     16.69   6727.69   6719.96       .00   6727.77       .07       .02       .01  6722.40
   15000.       35.    14964.        1.       36.     6914.        3.       38.        7.   6720.00
      .03       .97      2.16       .26      .040      .040      .040      .000   6711.00     29.29
  .000205       50.       50.       50.         4        11         0       .00    856.41    885.70

*SECNO 50.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.53

    50.00     22.73   6727.73   6715.62       .00   6727.78       .04       .01       .00  6732.00
   15000.        0.    15000.        0.        0.     9177.        0.       48.        8.   6731.00
      .04       .00      1.63       .00      .000      .040      .000      .000   6705.00     11.11
  .000088       50.       50.       50.         3        14         0       .00    895.92    907.03
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T1      MIDDLE CREEK DAM
T2      AUXILIARY SPILLWAY - FINAL DESIGN - ALTERNATIVE C
T3      HKM ASSOCIATES - 4/88

J1  ICHECK     INQ      NINV      IDIR      STRT    METRIC     HVINS      Q        WSEL       FQ

        0        8        0         0        -1        0        0.5        0    6715.0
MULTIPLE PROFILE RUN WITH INTERPOLATED CROSS SECTIONS

J2  NPROF     IPLOT     PRFVS     XSECV     XSECH     FN     ALLDC      IBW      CHNIM     ITRACE

       7                  -1                                    -1
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  SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
  Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
  TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
  SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*PROF 7

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS



CCHV=      .100 CEHV=      .300
*SECNO 1140.000
3720 CRITICAL DEPTH ASSUMED
    1140.00       9.58  6710.08  6710.08  6715.00  6713.22      3.14        .00        .00  6714.00
     20000.         0.   12780.    7220.       0.     814.      650.         0.         0.   6700.50
        .00        .00    15.70    11.11     .000     .040      .040      .000   6700.50     29.18
    .011107         0.       0.       0.        0       13         0       .00    235.42    264.60


*SECNO 1050.000

1645 INT SEC ADDED BY RAISING SEC   1050.00,   -.150 FT AND MULTIPLYING BY    .919


3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
       1.01      11.29  6711.94  6711.94      .00  6715.93      3.99        .50        .26  6716.85
     20000.         0.   15913.    4087.       0.     943.      335.         1.         0.   6700.65
        .00        .00    16.88    12.19     .000     .040      .040      .000   6700.65     35.09
    .010977        45.      45.      45.        0       11         0       .00    162.11    197.21



1645 INT SEC ADDED BY RAISING SEC      1.01,    .150 FT AND MULTIPLYING BY   1.088


3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.61

    1050.00      13.73  6714.53  6711.62      .00  6716.43      1.90        .29        .21  6717.00
     20000.         0.   15339.    4661.       0.    1310.      540.         3.         0.   6700.80
        .00        .00    11.71     8.63     .000     .040      .040      .000   6700.80     29.16
    .004224        45.      45.      45.        5        8         0       .00    199.49    228.65
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST

 *SECNO 972.000

 1645 INT SEC ADDED BY RAISING SEC     972.00,   -.100 FT AND MULTIPLYING BY     .913


 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   .66

       1.01     12.53  6713.43  6712.76       .00  6717.24      3.80       .24       .57  6717.90
     20000.        0.   20000.       0.        0.     1278.        0.        4.        1.   6714.90
        .00       .00    15.65      .00      .000      .040      .000      .000   6700.90     41.54
    .009576       39.       39.      39.        3        11        0       .00    138.98    180.52


 1645 INT SEC ADDED BY RAISING SEC       1.01,     .100 FT AND MULTIPLYING BY   1.095


 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.47

     972.00     14.54  6715.54  6712.24       .00  6717.65      2.11       .25       .17  6718.00
     20000.        0.   19999.       1.        0.     1715.        1.        6.        1.   6715.00
        .00       .00    11.66     1.01      .000      .040      .040      .000   6701.00     38.55
    .004439       39.       39.      39.        4        11        0       .00    166.05    204.61

 *SECNO 850.000

 1645 INT SEC ADDED BY RAISING SEC     850.00,  -2.700 FT AND MULTIPLYING BY   1.312


 3301 HV CHANGED MORE THAN HVINS

       1.01     14.72  6716.62  6711.76       .00  6717.84      1.22       .10       .09  6720.30
     20000.        0.   20000.       0.        0.     2254.        0.        7.        1.   6729.30
        .00       .00     8.87      .00      .000      .040      .000      .000   6701.90     78.75
    .002609       31.       31.      31.        2        14        0       .00    219.66    298.41
   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


1645 INT SEC ADDED BY RAISING SEC       1.01,     .900 FT AND MULTIPLYING BY     .921

3301 HV CHANGED MORE THAN HVINS

     1.02     13.48  6716.28  6713.12       .00  6718.13      1.85       .10       .19  6721.20
   20000.        0.   20000.       0.        0.    1831.        0.        9.        1.   6730.20
      .01       .00    10.92       .00      .000     .040      .000      .000  6702.80     78.60
  .004369       31.      31.       31.        3       19         0       .00   191.92    270.52


1645 INT SEC ADDED BY RAISING SEC       1.02,     .900 FT AND MULTIPLYING BY     .914

3301 HV CHANGED MORE THAN HVINS

     1.03     11.81  6715.51  6714.56       .00  6718.72      3.21       .18       .41  6722.10
   20000.        0.   20000.       0.        0.    1392.        0.       10.        1.   6731.10
      .01       .00    14.37       .00      .000     .040      .000      .000  6703.70     79.32
  .008775       31.      31.       31.        4       15         0       .00   162.71    242.03


1645 INT SEC ADDED BY RAISING SEC       1.03,     .900 FT AND MULTIPLYING BY     .906

3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   850.00     11.51  6716.11  6716.11       .00  6720.31      4.20       .31       .30  6723.00
   20000.        0.   20000.       0.        0.    1216.        0.       11.        1.   6732.00
      .01       .00    16.45       .00      .000     .040      .000      .000  6704.60     73.08
  .011890       31.      31.       31.        0        8         0       .00   145.27    218.35

*SECNO 750.000

1645 INT SEC ADDED BY RAISING SEC     750.00,  -2.100 FT AND MULTIPLYING BY     .902
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    SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
    Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
    TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN        SSTA
    SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID       ENDST


 3301 HV CHANGED MORE THAN HVINS


 3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   1.82

      1.01     13.51   6718.81   6715.68       .00   6720.69      1.88       .15       .23   6712.90
    20000.      500.    17434.     2067.      110.     1519.      273.       12.        1.    6705.60
       .01      4.54     11.48      7.58      .040      .040      .040      .000   6705.30     89.04
   .003586       25.       25.       25.         4        11         0       .00    207.63    296.67


 1645 INT SEC ADDED BY RAISING SEC       1.01,     .700 FT AND MULTIPLYING BY    1.036

      1.02     12.80   6718.80   6716.18       .00   6720.84      2.04       .10       .05   6713.60
    20000.      398.    17600.     2002.       88.     1479.      253.       13.        1.    6706.30
       .01      4.51     11.90      7.91      .040      .040      .040      .000   6706.00     96.87
   .004181       25.       25.       25.         3        15         0       .00    208.22    305.09


 1645 INT SEC ADDED BY RAISING SEC       1.02,     .700 FT AND MULTIPLYING BY    1.035

      1.03     12.07   6718.77   6716.68       .00   6721.01      2.24       .11       .06   6714.30
    20000.      302.    17766.     1932.       68.     1430.      232.       14.        2.    6707.00
       .01      4.45     12.42      8.31      .040      .040      .040      .000   6706.70    105.16
   .004987       25.       25.       25.         3        15         0       .00    208.12    313.28


 1645 INT SEC ADDED BY RAISING SEC       1.03,     .700 FT AND MULTIPLYING BY    1.034

    750.00     11.33   6718.73   6717.20       .00   6721.22      2.49       .14       .08   6715.00
    20000.      212.    17929.     1859.       49.     1372.      211.       15.        2.    6707.70
       .01      4.36     13.07      8.81      .040      .040      .040      .000   6707.40    113.90
   .006093       25.       25.       25.         3        15         0       .00    207.35    321.24

 *SECNO 650.000

 1645 INT SEC ADDED BY RAISING SEC     650.00,   -1.867 FT AND MULTIPLYING BY    1.060
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS   BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA   LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


     1.01     11.01   6719.35   6717.13       .00   6721.45      2.10       .19       .04  6723.13
   20000.        0.    19551.      449.        0.     1667.       74.       16.        2.   6712.13
      .01       .00     11.73      6.04      .000      .040      .040      .000   6708.33    159.95
  .005165       33.       33.       33.         2        15         0       .00    199.95    359.91


1645 INT SEC ADDED BY RAISING SEC       1.01,     .933 FT AND MULTIPLYING BY     .972


3301 HV CHANGED MORE THAN HVINS

     1.02      9.56   6718.83   6718.22       .00   6721.99      3.17       .23       .32  6724.07
   20000.        0.    19682.      318.        0.     1369.       46.       17.        2.   6713.07
      .01       .00     14.37      6.93      .000      .040      .040      .000   6709.27    161.69
  .009225       33.       33.       33.         4        15         0       .00    183.92    345.61


1645 INT SEC ADDED BY RAISING SEC       1.02,     .933 FT AND MULTIPLYING BY     .971


3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   650.00      9.15   6719.35   6719.35       .00   6723.09      3.74       .34       .17  6725.00
   20000.        0.    19717.      283.        0.     1263.       38.       18.        2.   6714.00
      .01       .00     15.62      7.35      .000      .040      .040      .000   6710.20    158.67
  .011504       33.       33.       33.         0         8         0       .00    175.70    334.38


*SECNO 600.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   600.00      8.25   6720.25   6720.25       .00   6723.86      3.61       .58       .01  6727.00
   20000.        0.    18858.     1142.        0.     1215.      113.       20.        2.   6712.00
      .01       .00     15.52     10.08      .000      .040      .040      .000   6712.00    110.26
  .011786       70.       50.       40.         0        11         0       .00    187.23    297.49


*SECNO 480.000
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  SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
  Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
  TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN         SSTA
  SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID        ENDST


1645 INT SEC ADDED BY RAISING SEC    480.00,  -2.250 FT AND MULTIPLYING BY    .748


3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.50

     1.01      9.36  6722.11  6720.18       .00  6724.24      2.12       .23       .15  6712.75
   20000.      646.   18602.     752.       92.    1554.      105.       21.        2.   6712.75
      .01      7.04    11.97     7.15      .040     .040      .040      .000   6712.75    35.00
  .005264       33.      30.      25.         4       11         0       .00    208.10   243.10


1645 INT SEC ADDED BY RAISING SEC       1.01,    .750 FT AND MULTIPLYING BY   1.112

     1.02      9.09  6722.59  6720.44       .00  6724.41      1.83       .15       .03  6713.50
   20000.      636.   18626.     738.       96.    1679.      110.       22.        3.   6713.50
      .01      6.61    11.09     6.69      .040     .040      .040      .000   6713.50    39.56
  .004700       33.      30.      25.         2       15         0       .00    230.14   269.69


1645 INT SEC ADDED BY RAISING SEC       1.02,    .750 FT AND MULTIPLYING BY   1.101

     1.03      8.63  6722.88  6720.78       .00  6724.57      1.68       .14       .01  6714.25
   20000.      611.   18680.     708.       96.    1756.      110.       23.        3.   6714.25
      .01      6.39    10.64     6.46      .040     .040      .040      .000   6714.25    44.72
  .004630       33.      30.      25.         3       15         0       .00    250.88   295.60


1645 INT SEC ADDED BY RAISING SEC       1.03,    .750 FT AND MULTIPLYING BY   1.092

   480.00      8.09  6723.09  6721.17       .00  6724.72      1.63       .14       .01  6715.00
   20000.      579.   18751.     670.       92.    1796.      105.       25.        3.   6715.00
      .01      6.32    10.44     6.38      .040     .040      .040      .000   6715.00    50.34
  .004859       33.      30.      25.         3       15         0       .00    270.64   320.98
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   SECNO    DEPTH    CWSEL    CRIWS    WSELK    EG       HV       HL       OLOSS   BANK ELEV
   Q        QLOB     QCH      QROB     ALOB     ACH      AROB     VOL      TWA   LEFT/RIGHT
   TIME     VLOB     VCH      VROB     XNL      XNCH     XNR      WTN      ELMIN      SSTA
   SLOPE    XLOBL    XLCH     XLOBR    ITRIAL   IDC      ICONT    CORAR    TOPWID     ENDST


*SECNO 250.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   250.00     3.66  6725.46  6725.46      .00  6727.28     1.82     1.90      .06  6721.80
   20000.     111.   19776.     113.      17.    1820.      17.      35.       5.   6721.80
      .02     6.52    10.87     6.53     .040     .040     .040     .000  6721.80    26.72
  .015167     310.     240.     160.        0       14        0      .00   515.74   542.45


*SECNO 200.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   200.00     3.48  6726.48  6726.48      .00  6728.15     1.67      .76      .02  6723.00
   20000.      98.   19330.     572.      16.    1846.      87.      37.       6.   6723.00
      .02     6.29    10.47     6.59     .040     .040     .040     .000  6723.00    32.08
  .015055      60.      50.      50.        0        8        0      .00   588.84   620.91


*SECNO 165.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.61

   165.00     4.61  6727.61  6726.47      .00  6728.53      .93      .31      .07  6723.00
   20000.     128.   19123.     749.      27.    2442.     152.      39.       6.   6723.00
      .02     4.70     7.83     4.92     .040     .040     .040     .000  6723.00    29.19
  .005793      35.      35.      35.        5        5        0      .00   607.85   637.05


CCHV=     .100 CEHV=     .300
*SECNO 150.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.32

   150.00     8.36  6728.36  6724.57      .00  6728.63      .28      .03      .07  6736.00
   20000.       0.   20000.       0.       0.    4750.       0.      40.       6.   6731.00
      .02      .00     4.21      .00     .000     .040     .000     .000  6720.00    20.43
  .001077      15.      15.      15.        4        5        0      .00   738.41   758.84
  SECNO   DEPTH   CWSEL   CRIWS   WSELK   EG      HV      HL      OLOSS  BANK ELEV
  Q       QLOB    QCH     QROB    ALOB    ACH     AROB    VOL     TWA  LEFT/RIGHT
  TIME    VLOB    VCH     VROB    XNL     XNCH    XNR     WTN     ELMIN     SSTA
  SLOPE   XLOBL   XLCH    XLOBR   ITRIAL  IDC     ICONT   CORAR   TOPWID    ENDST

*SECNO 100.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.03

  100.00   17.57 6728.57 6720.84     .00 6728.67     .11     .02     .02 6722.40
  20000.     60.  19939.      1.     49.   7648.      3.     48.      7.  6720.00
     .03    1.21    2.61     .32    .040    .040    .040    .000 6711.00   27.03
 .000260     50.     50.     50.       4       8       0     .00  858.75  885.78

*SECNO 50.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.48

   50.00   23.62 6728.62 6716.79     .00 6728.68     .06     .01     .00 6732.00
  20000.      0.  20000.      0.      0.   9974.      0.     58.      8.  6731.00
     .04     .00    2.01     .00    .000    .040    .000    .000 6705.00    8.80
 .000119     50.     50.     50.       3      19       0     .00  899.04  907.84
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T1        MIDDLE CREEK DAM
T2        AUXILIARY SPILLWAY - FINAL DESIGN - ALTERNATIVE C
T3        HKM ASSOCIATES - 4/88

J1   ICHECK     INQ        NINV       IDIR       STRT       METRIC     HVINS      Q          WSEL       FQ

          0          9          0          0         -1          0        0.5          0     6715.0
MULTIPLE PROFILE RUN WITH INTERPOLATED CROSS SECTIONS

J2   NPROF      IPLOT      PRFVS      XSECV      XSECH      FN         ALLDC      IBW        CHNIM      ITRACE

        15                    -1                                           -1
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


*PROF 8

CRITICAL DEPTH TO BE CALCULATED AT ALL CROSS SECTIONS



CCHV=      .100 CEHV=      .300
*SECNO 1140.000
3720 CRITICAL DEPTH ASSUMED
  1140.00     11.21  6711.71  6711.71  6715.00  6715.28      3.58       .00       .00  6714.00
   27300.        0.   16537.   10763.       0.     980.      888.        0.        0.   6700.50
     .00       .00    16.88    12.12     .000     .040      .040      .000   6700.50     24.14
  .010723        0.       0.       0.        0       14         0       .00    263.41    287.54


*SECNO 1050.000

1645 INT SEC ADDED BY RAISING SEC   1050.00,   -.150 FT AND MULTIPLYING BY    .909


3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
     1.01     13.40  6714.05  6714.05      .00  6718.66      4.61       .48       .31  6716.85
   27300.        0.   21037.    6263.       0.    1155.      468.        2.        0.   6700.65
     .00       .00    18.21    13.39     .000     .040      .040      .000   6700.65     27.61
  .010532       45.      45.      45.        0       11         0       .00    178.59    206.21


1645 INT SEC ADDED BY RAISING SEC      1.01,    .150 FT AND MULTIPLYING BY   1.100


3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.63

  1050.00     16.24  6717.04  6713.60      .00  6719.18      2.13       .27       .25  6717.00
   27300.        0.   20237.    7063.       0.    1626.      756.        4.        0.   6700.80
     .00       .02    12.44     9.34     .040     .040      .040      .000   6700.80     19.06
  .003949       45.      45.      45.        5        8         0       .00    224.02    243.08
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 SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
 Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
 TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
 SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


*SECNO 972.000

1645 INT SEC ADDED BY RAISING SEC     972.00,    -.133 FT AND MULTIPLYING BY     .876


3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
     1.01     14.40   6715.27   6715.27       .00   6720.53      5.26       .16       .94  6717.87
  27300.         0.    27300.        0.        0.     1483.        0.        5.        1.   6714.87
      .00       .00     18.41      1.33      .000      .040      .040      .000   6700.87     34.16
  .011332       26.       26.       26.         0        11         0       .00    144.41    178.57


1645 INT SEC ADDED BY RAISING SEC       1.01,     .067 FT AND MULTIPLYING BY    1.071


3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =   1.58

     1.02     17.27   6718.21   6714.87       .00   6720.96      2.76       .18       .25  6717.93
  27300.         0.    27216.       84.        1.     2040.       24.        6.        1.   6714.93
      .00       .66     13.34      3.43      .040      .040      .040      .000   6700.93     24.32
  .004558       26.       26.       26.         6         8         0       .00    180.04    204.36


1645 INT SEC ADDED BY RAISING SEC       1.02,     .067 FT AND MULTIPLYING BY    1.066


3301 HV CHANGED MORE THAN HVINS

   972.00     17.95   6718.95   6714.41       .00   6721.12      2.17       .10       .06  6718.00
  27300.         9.    27165.      126.        7.     2292.       38.        7.        1.   6715.00
      .00      1.30     11.85      3.33      .040      .040      .040      .000   6701.00     15.78
  .003341       26.       26.       26.         3        15         0       .00    205.43    221.21
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


*SECNO 850.000

1645 INT SEC ADDED BY RAISING SEC    850.00,  -2.700 FT AND MULTIPLYING BY   1.367


3301 HV CHANGED MORE THAN HVINS

     1.01     18.29   6720.19   6713.37       .00   6721.30      1.11       .07       .11   6720.30
   27300.        0.    27300.        0.        0.     3223.        0.        9.        1.    6729.30
      .00       .00      8.47       .00      .000      .040      .000      .000   6701.90     62.11
  .001870       31.       31.       31.         2        14         0       .00    262.29    324.40


1645 INT SEC ADDED BY RAISING SEC      1.01,    .900 FT AND MULTIPLYING BY    .911


3301 HV CHANGED MORE THAN HVINS

     1.02     17.09   6719.89   6714.89       .00   6721.53      1.64       .07       .16   6721.20
   27300.        0.    27300.        0.        0.     2655.        0.       11.        1.    6730.20
      .01       .00     10.28       .00      .000      .040      .000      .000   6702.80     62.64
  .002982       31.       31.       31.         3        14         0       .00    228.56    291.20


1645 INT SEC ADDED BY RAISING SEC      1.02,    .900 FT AND MULTIPLYING BY    .902


3301 HV CHANGED MORE THAN HVINS

     1.03     15.62   6719.32   6716.51       .00   6721.94      2.62       .12       .29   6722.10
   27300.        0.    27300.        0.        0.     2100.        0.       13.        1.    6731.10
      .01       .00     13.00       .00      .000      .040      .000      .000   6703.70     63.21
  .005287       31.       31.       31.         3        15         0       .00    194.78    257.99


1645 INT SEC ADDED BY RAISING SEC      1.03,    .900 FT AND MULTIPLYING BY    .891


3301 HV CHANGED MORE THAN HVINS
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   SECNO     DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q         QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA    LEFT/RIGHT
   TIME      VLOB      VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN        SSTA
   SLOPE     XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID       ENDST


7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   850.00     13.65  6718.25  6718.25       .00  6723.11      4.86       .23       .67  6723.00
   27300.        0.   27300.        0.        0.    1543.        0.       14.        1.   6732.00
     .01       .00     17.70       .00      .000      .040      .000      .000  6704.60     64.36
  .011428       31.       31.       31.        0        11         0       .00   160.01    224.36


*SECNO 750.000

1645 INT SEC ADDED BY RAISING SEC    750.00,  -2.100 FT AND MULTIPLYING BY    .929

3301 HV CHANGED MORE THAN HVINS

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.00

     1.01     16.29  6721.59  6717.44       .00  6723.53      1.94       .13       .29  6712.90
   27300.     1288.   22841.    3171.      245.    1933.      412.       16.        1.   6705.60
     .01      5.25     11.81      7.70      .040      .040      .040      .000  6705.30     73.56
  .002860       25.       25.       25.        4        11         0       .00   240.83    314.39


1645 INT SEC ADDED BY RAISING SEC       1.01,    .700 FT AND MULTIPLYING BY   1.025

     1.02     15.55  6721.55  6718.00       .00  6723.66      2.11       .08       .05  6713.60
   27300.     1121.   23092.    3087.      211.    1882.      384.       17.        2.   6706.30
     .01      5.32     12.27      8.04      .040      .040      .040      .000  6706.00     80.35
  .003304       25.       25.       25.        3        15         0       .00   239.62    319.97


1645 INT SEC ADDED BY RAISING SEC       1.02,    .700 FT AND MULTIPLYING BY   1.025

     1.03     14.80  6721.50  6718.50       .00  6723.81      2.31       .09       .06  6714.30
   27300.      954.   23349.    2997.      177.    1823.      356.       18.        2.   6707.00
     .01      5.39     12.80      8.43      .040      .040      .040      .000  6706.70     87.51
  .003879       25.       25.       25.        3        15         0       .00   237.85    325.37
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA     LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


1645 INT SEC ADDED BY RAISING SEC       1.03,     .700 FT AND MULTIPLYING BY    1.024

   750.00      14.03   6721.43   6719.05        .00   6723.99       2.57        .11        .08  6715.00
   27300.       789.    23609.     2902.       144.     1757.       326.        20.         2.    6707.70
      .01       5.47     13.44      8.89       .040      .040       .040       .000    6707.40     95.05
  .004632        25.       25.       25.          3        15          0        .00     235.53    330.58

*SECNO 650.000

1645 INT SEC ADDED BY RAISING SEC     650.00,  -2.100 FT AND MULTIPLYING BY    1.092

3301 HV CHANGED MORE THAN HVINS

     1.01      14.08   6722.18   6718.53        .00   6724.16       1.98        .10        .06  6722.90
   27300.         0.    26301.      999.         0.     2302.       155.        21.         2.    6711.90
      .01        .00     11.43      6.45       .000      .040       .040       .000    6708.10    150.67
  .003651        25.       25.       25.          2        15          0        .00     228.80    379.47


1645 INT SEC ADDED BY RAISING SEC       1.01,     .700 FT AND MULTIPLYING BY     .972

3301 HV CHANGED MORE THAN HVINS

     1.02      13.11   6721.91   6719.40        .00   6724.42       2.52        .11        .16  6723.60
   27300.         0.    26425.      875.         0.     2052.       124.        22.         2.    6712.60
      .01        .00     12.88      7.08       .000      .040       .040       .000    6708.80    150.77
  .005050        25.       25.       25.          3        15          0        .00     215.32    366.09


1645 INT SEC ADDED BY RAISING SEC       1.02,     .700 FT AND MULTIPLYING BY     .971

3301 HV CHANGED MORE THAN HVINS

     1.03      11.96   6721.46   6720.29        .00   6724.83       3.37        .15        .26  6724.30
   27300.         0.    26570.      730.         0.     1787.        92.        24.         2.    6713.30
      .01        .00     14.87      7.90       .000      .040       .040       .000    6709.50    151.35
  .007514        25.       25.       25.          3        15          0        .00     201.04    352.39
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB   .   VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


1645 INT SEC ADDED BY RAISING SEC       1.03,     .700 FT AND MULTIPLYING BY     .970


3301 HV CHANGED MORE THAN HVINS

7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   650.00     10.98  6721.19  6721.19        .00  6725.62       4.44       .22       .32  6725.00
   27300.        0.   26694.     606.         0.    1566.        69.       25.        2.   6714.00
     .01        .00    17.05     8.74       .000     .040       .040      .000   6710.20    150.99
  .010964       25.      25.      25.          0       11          0       .00    188.32    339.31


*SECNO 600.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   600.00     10.01  6722.01  6722.01        .00  6726.29       4.28       .55       .02  6727.00
   27300.        0.   25442.    1858.         0.    1502.       167.       26.        3.   6712.00
     .01        .00    16.94    11.12       .000     .040       .040      .000   6712.00    104.96
  .011083       70.      50.      40.          0       11          0       .00    198.41    303.37


*SECNO 480.000

1645 INT SEC ADDED BY RAISING SEC     480.00,  -2.250 FT AND MULTIPLYING BY     .757


3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,   KRATIO =   1.54

     1.01     11.48  6724.23  6721.77        .00  6726.68       2.45       .20       .18  6712.75
   27300.     1148.   24915.    1237.       145.    1929.       160.       28.        3.   6712.75
     .01       7.93    12.92     7.72       .040     .040       .040      .000   6712.75     23.98
  .004668       33.      30.      25.          4       11          0       .00    227.18    251.16


1645 INT SEC ADDED BY RAISING SEC       1.01,     .750 FT AND MULTIPLYING BY   1.107

     1.02     11.27  6724.77  6721.95        .00  6726.85       2.08       .13       .04  6713.50
   27300.     1131.   24943.    1227.       153.    2097.       171.       29.        3.   6713.50
     .01       7.38    11.90     7.18       .040     .040       .040      .000   6713.50     28.11
  .004056       33.      30.      25.          2       15          0       .00    249.39    277.50
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   SECNO      DEPTH      CWSEL      CRIWS      WSELK      EG         HV         HL         OLOSS    BANK ELEV
   Q          QLOB       QCH        QROB       ALOB       ACH        AROB       VOL        TWA    LEFT/RIGHT
   TIME       VLOB       VCH        VROB       XNL        XNCH       XNR        WTN        ELMIN        SSTA
   SLOPE      XLOBL      XLCH       XLOBR      ITRIAL     IDC        ICONT      CORAR      TOPWID       ENDST


1645 INT SEC ADDED BY RAISING SEC       1.02,     .750 FT AND MULTIPLYING BY    1.097

     1.03      10.86    6725.11    6722.20        .00    6726.99       1.88        .12        .02   6714.25
   27300.      1082.     25023.      1195.       154.      2217.       174.        31.         3.    6714.25
      .01       7.02      11.29       6.86       .040       .040       .040       .000    6714.25      34.18
  .003834        33.        30.        25.          2         19          0        .00     268.97     303.15


1645 INT SEC ADDED BY RAISING SEC       1.03,     .750 FT AND MULTIPLYING BY    1.088

   480.00      10.34    6725.34    6722.53        .00    6727.11       1.77        .11        .01   6715.00
   27300.      1014.     25138.      1149.       150.      2297.       172.        33.         3.    6715.00
      .01       6.75      10.95       6.69       .040       .040       .040       .000    6715.00      41.89
  .003850        33.        30.        25.          3         19          0        .00     286.32     328.21

*SECNO 250.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,   KRATIO =    .60

   250.00       4.91    6726.71    6726.30        .00    6728.58       1.87       1.43        .03   6721.80
   27300.       202.     26892.       206.        31.      2440.        31.        47.         5.    6721.80
      .02       6.62      11.02       6.63       .040       .040       .040       .000    6721.80      23.56
  .010552       310.       240.       160.          5         14          0        .00     522.12     545.68


*SECNO 200.000
7185 MINIMUM SPECIFIC ENERGY
3720 CRITICAL DEPTH ASSUMED
   200.00       4.26    6727.26    6727.26        .00    6729.30       2.04        .61        .05   6723.00
   27300.       162.     26190.       948.        23.      2256.       130.        50.         6.    6723.00
      .02       6.98      11.61       7.30       .040       .040       .040       .000    6723.00      30.09
  .014163        60.        50.        50.          0         11          0        .00     601.91     632.00


*SECNO 165.000

3301 HV CHANGED MORE THAN HVINS
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   SECNO      DEPTH     CWSEL     CRIWS     WSELK     EG        HV        HL        OLOSS    BANK ELEV
   Q          QLOB      QCH       QROB      ALOB      ACH       AROB      VOL       TWA     LEFT/RIGHT
   TIME       VLOB .    VCH       VROB      XNL       XNCH      XNR       WTN       ELMIN       SSTA
   SLOPE      XLOBL     XLCH      XLOBR     ITRIAL    IDC       ICONT     CORAR     TOPWID      ENDST


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.55

   165.00      5.50  6728.50  6727.26       .00  6729.69      1.18       .30       .09  6723.00
   27300.      207.   25881.    1212.       39.    2918.      217.       52.        7.   6723.00
      .02      5.33     8.87     5.58      .040     .040      .040      .000   6723.00    26.89
  .005865       35.      35.      35.         5        5         0       .00    623.01    649.90

CCHV=     .100 CEHV=     .300
*SECNO 150.000

3301 HV CHANGED MORE THAN HVINS


3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  2.19

   150.00      9.43  6729.43  6725.27       .00  6729.80       .38       .03       .08  6736.00
   27300.        0.   27300.       0.        0.    5546.        0.       53.        7.   6731.00
      .02       .00     4.92      .00      .000     .040      .000      .000   6720.00    17.57
  .001222       15.      15.      15.         4       11         0       .00    749.83    767.40

*SECNO 100.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.93

   100.00     18.70  6729.70  6721.75       .00  6729.85       .15       .03       .02  6722.40
   27300.      105.   27193.       2.       69.    8601.        4.       62.        8.   6720.00
      .03      1.52     3.16      .39      .040     .040      .040      .000   6711.00    24.10
  .000327       50.      50.      50.         4       14         0       .00    861.79    885.88

*SECNO 50.000

3302 WARNING:  CONVEYANCE CHANGE OUTSIDE OF ACCEPTABLE RANGE,  KRATIO =  1.43

    50.00     24.77  6729.77  6718.15       .00  6729.87       .10       .01       .01  6732.00
   27300.        0.   27300.       0.        0.   11013.        0.       73.        9.   6731.00
      .03       .00     2.48      .00      .000     .040      .000      .000   6705.00     5.80
  .000161       50.      50.      50.         3       16         0       .00    903.09    908.89
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                                                                                  THIS RUN EXECUTED  9/13/90    10:39: 2
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  HEC2 RELEASE DATED SEP 88 UPDATED APR  1989


  ERROR CORR -  01,02
  MODIFICATION -
************************************************


NOTE- ASTERISK (*) AT LEFT OF CROSS-SECTION NUMBER INDICATES MESSAGE IN SUMMARY OF ERRORS LIST


 HKM ASSOCIATES - 4/88

SUMMARY PRINTOUT TABLE  150


      SECNO      XLCH      ELTRD      ELLC      ELMIN        Q       CWSEL     CRIWS      EG       10*KS      VCH      AREA      .01K

*   1140.000      .00       .00       .00     6700.50    100.00   6700.89   6700.89   6701.08   321.66      3.54     28.66      5.58
*   1140.000      .00       .00       .00     6700.50    500.00   6701.62   6701.62   6702.12   221.21      5.84     88.80     33.62
*   1140.000      .00       .00       .00     6700.50   1000.00   6702.23   6702.23   6702.98   187.58      7.15    147.36     73.01
*   1140.000      .00       .00       .00     6700.50   5000.00   6705.03   6705.03   6706.74   137.41     11.19    494.73    426.53
*   1140.000      .00       .00       .00     6700.50  10000.00   6707.16   6707.16   6709.50   122.31     13.31    849.27    904.22
*   1140.000      .00       .00       .00     6700.50  15000.00   6708.79   6708.79   6711.54   113.96     14.62   1172.54   1405.14
*   1140.000      .00       .00       .00     6700.50  20000.00   6710.08   6710.08   6713.22   111.07     15.70   1463.65   1897.74
*   1140.000      .00       .00       .00     6700.50  27300.00   6711.71   6711.71   6715.28   107.23     16.88   1868.10   2636.39

*   1050.000    90.00       .00       .00     6700.80    100.00   6701.63   6701.20   6701.67    26.31      1.65     61.17     19.50
*   1050.000    90.00       .00       .00     6700.80    500.00   6702.68   6701.94   6702.86    39.85      3.46    148.26     79.20
*   1050.000    90.00       .00       .00     6700.80   1000.00   6703.45   6702.58   6703.79    48.08      4.72    218.94    144.22
    1050.000    90.00       .00       .00     6700.80   5000.00   6706.29   6705.65   6707.75    88.78     10.01    527.14    530.66
*   1050.000    90.00       .00       .00     6700.80  10000.00   6708.12   6708.12   6710.90   122.64     13.93    764.55    902.98
    1050.000    90.00       .00       .00     6700.80  15000.00   6712.49   6710.03   6714.20    45.18     11.07   1463.08   2231.65
    1050.000    90.00       .00       .00     6700.80  20000.00   6714.53   6711.62   6716.43    42.24     11.71   1849.81   3077.35
    1050.000    90.00       .00       .00     6700.80  27300.00   6717.04   6713.60   6719.18    39.49     12.44   2382.28   4344.07

     972.000    78.00       .00       .00     6701.00    100.00   6701.83   6701.39   6701.88    26.42      1.64     60.98     19.46
     972.000    78.00       .00       .00     6701.00    500.00   6702.99   6702.13   6703.15    34.32      3.25    153.96     85.34
     972.000    78.00       .00       .00     6701.00   1000.00   6703.83   6702.78   6704.14    41.12      4.41    226.89    155.94
     972.000    78.00       .00       .00     6701.00   5000.00   6707.13   6705.94   6708.38    69.19      8.98    557.06    601.10
     972.000    78.00       .00       .00     6701.00  10000.00   6710.91   6708.54   6712.40    48.11      9.78   1022.16   1441.79
     972.000    78.00       .00       .00     6701.00  15000.00   6713.38   6710.54   6715.23    46.88     10.91   1375.19   2190.78
     972.000    78.00       .00       .00     6701.00  20000.00   6715.54   6712.24   6717.65    44.39     11.66   1715.87   3001.75
     972.000    78.00       .00       .00     6701.00  27300.00   6718.95   6714.41   6721.12    33.41     11.85   2336.17   4723.28
     SECNO     XLCH     ELTRD     ELLC     ELMIN       Q      CWSEL     CRIWS       EG      10*KS      VCH      AREA     .01K

*   850.000   122.00     .00       .00   6704.60    100.00  6705.01   6705.01   6705.21   316.68     3.60     27.75     5.62
*   850.000   122.00     .00       .00   6704.60    500.00  6705.79   6705.79   6706.35   225.99     6.01     83.19    33.26
    850.000   122.00     .00       .00   6704.60   1000.00  6706.46   6706.46   6707.32   197.93     7.43    134.55    71.08
    850.000   122.00     .00       .00   6704.60   5000.00  6709.71   6709.71   6711.84   148.69    11.71    426.86   410.04
    850.000   122.00     .00       .00   6704.60  10000.00  6712.32   6712.32   6715.36   133.41    13.99    714.81   865.79
    850.000   122.00     .00       .00   6704.60  15000.00  6714.35   6714.35   6718.06   125.79    15.45    970.95  1337.41
    850.000   122.00     .00       .00   6704.60  20000.00  6716.11   6716.11   6720.31   118.90    16.45   1215.99  1834.14
    850.000   122.00     .00       .00   6704.60  27300.00  6718.25   6718.25   6723.11   114.28    17.70   1542.66  2553.80

    750.000   100.00     .00       .00   6707.40    100.00  6707.81   6707.78   6707.96   240.01     3.10     32.28     6.45
*   750.000   100.00     .00       .00   6707.40    500.00  6708.47   6708.47   6708.97   231.70     5.67     88.67    32.85
*   750.000   100.00     .00       .00   6707.40   1000.00  6709.07   6709.07   6709.82   200.83     6.99    144.52    70.56
*   750.000   100.00     .00       .00   6707.40   5000.00  6711.91   6711.91   6713.71   148.86    10.93    467.89   409.81
    750.000   100.00     .00       .00   6707.40  10000.00  6714.13   6714.13   6716.68   133.43    13.01    789.96   865.72
    750.000   100.00     .00       .00   6707.40  15000.00  6716.63   6715.78   6719.07    81.95    12.84   1217.66  1656.99
    750.000   100.00     .00       .00   6707.40  20000.00  6718.73   6717.20   6721.22    60.93    13.07   1631.56  2562.11
    750.000   100.00     .00       .00   6707.40  27300.00  6721.43   6719.05   6723.99    46.32    13.44   2227.81  4011.05

    650.000   100.00     .00       .00   6710.20    100.00  6710.52   6710.51   6710.66   304.07     3.00     33.37     5.73
*   650.000   100.00     .00       .00   6710.20    500.00  6711.09   6711.09   6711.52   246.45     5.25     95.27    31.85
*   650.000   100.00     .00       .00   6710.20   1000.00  6711.59   6711.59   6712.26   215.97     6.54    152.83    68.05
*   650.000   100.00     .00       .00   6710.20   5000.00  6714.11   6714.11   6715.83   157.93    10.53    474.86   397.86
*   650.000   100.00     .00       .00   6710.20  10000.00  6716.18   6716.18   6718.76   134.99    12.92    778.30   860.69
    650.000   100.00     .00       .00   6710.20  15000.00  6717.89   6717.89   6721.10   121.98    14.42   1051.58  1358.14
    650.000   100.00     .00       .00   6710.20  20000.00  6719.35   6719.35   6723.09   115.04    15.62   1301.09  1864.69
    650.000   100.00     .00       .00   6710.20  27300.00  6721.19   6721.19   6725.62   109.64    17.05   1635.08  2607.18

*   600.000    50.00     .00       .00   6712.00    100.00  6712.26   6712.26   6712.38   371.91     2.88     34.75     5.19
*   600.000    50.00     .00       .00   6712.00    500.00  6712.75   6712.75   6713.12   256.94     4.88    102.83    31.19
*   600.000    50.00     .00       .00   6712.00   1000.00  6713.19   6713.19   6713.76   219.89     6.11    164.50    67.44
*   600.000    50.00     .00       .00   6712.00   5000.00  6715.40   6715.40   6717.00   156.32    10.23    495.82   399.91
*   600.000    50.00     .00       .00   6712.00  10000.00  6717.32   6717.32   6719.75   135.40    12.65    807.38   859.40
*   600.000    50.00     .00       .00   6712.00  15000.00  6718.88   6718.88   6721.96   125.11    14.29   1077.97  1341.03
*   600.000    50.00     .00       .00   6712.00  20000.00  6720.25   6720.25   6723.86   117.86    15.52   1328.73  1842.28
*   600.000    50.00     .00       .00   6712.00  27300.00  6722.01   6722.01   6726.29   110.83    16.94   1669.09  2593.21

*   480.000   120.00     .00       .00   6715.00    100.00  6715.24   6715.18   6715.29   169.41     1.87     53.61     7.68
    480.000   120.00     .00       .00   6715.00    500.00  6715.60   6715.54   6715.81   195.91     3.71    135.08    35.72
    480.000   120.00     .00       .00   6715.00   1000.00  6715.91   6715.85   6716.28   197.88     4.91    204.66    71.09
    480.000   120.00     .00       .00   6715.00   5000.00  6717.47   6717.47   6718.69   172.79     8.93    567.19   380.37
    480.000   120.00     .00       .00   6715.00  10000.00  6719.38   6718.91   6720.88    99.85     9.93   1029.26  1000.76
    480.000   120.00     .00       .00   6715.00  15000.00  6721.32   6720.10   6722.87    64.16    10.17   1522.14  1872.72
    480.000   120.00     .00       .00   6715.00  20000.00  6723.09   6721.17   6724.72    48.59    10.44   1993.16  2869.20
    480.000   120.00     .00       .00   6715.00  27300.00  6725.34   6722.53   6727.11    38.50    10.95   2618.64  4399.63
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     SECNO      XLCH     ELTRD      ELLC     ELMIN         Q     CWSEL     CRIWS        EG     10*KS       VCH      AREA      .01K

*  250.000    240.00       .00       .00   6721.80    100.00   6721.91   6721.91   6721.96    448.48      1.82     55.12      4.72
*  250.000    240.00       .00       .00   6721.80    500.00   6722.12   6722.12   6722.27    330.53      3.15    158.73     27.50
*  250.000    240.00       .00       .00   6721.80   1000.00   6722.30   6722.30   6722.55    299.62      4.04    247.92     57.77
*  250.000    240.00       .00       .00   6721.80   5000.00   6723.26   6723.26   6723.99    205.40      6.86    731.55    348.87
*  250.000    240.00       .00       .00   6721.80  10000.00   6724.11   6724.11   6725.27    177.83      8.65   1161.01    749.89
*  250.000    240.00       .00       .00   6721.80  15000.00   6724.83   6724.83   6726.33    160.35      9.86   1531.04   1184.56
*  250.000    240.00       .00       .00   6721.80  20000.00   6725.46   6725.46   6727.28    151.67     10.87   1853.88   1623.99
*  250.000    240.00       .00       .00   6721.80  27300.00   6726.71   6726.30   6728.58    105.52     11.02   2501.27   2657.62

*  200.000     50.00       .00       .00   6723.00    100.00   6723.14   6723.11   6723.17    150.23      1.27     78.60      8.16
   200.000     50.00       .00       .00   6723.00    500.00   6723.37   6723.30   6723.47    179.79      2.56    196.01     37.29
   200.000     50.00       .00       .00   6723.00   1000.00   6723.55   6723.48   6723.73    189.08      3.42    293.16     72.72
*  200.000     50.00       .00       .00   6723.00   5000.00   6724.40   6724.40   6725.08    206.31      6.67    756.34    348.10
*  200.000     50.00       .00       .00   6723.00  10000.00   6725.21   6725.21   6726.28    176.97      8.37   1209.77    751.71
*  200.000     50.00       .00       .00   6723.00  15000.00   6725.88   6725.88   6727.27    161.02      9.55   1597.53   1182.09
*  200.000     50.00       .00       .00   6723.00  20000.00   6726.48   6726.48   6728.15    150.55     10.47   1948.13   1630.02
*  200.000     50.00       .00       .00   6723.00  27300.00   6727.26   6727.26   6729.30    141.63     11.61   2408.62   2293.99

*  165.000     35.00       .00       .00   6723.00    100.00   6723.29   6723.10   6723.30     15.88       .65    154.43     25.09
*  165.000     35.00       .00       .00   6723.00    500.00   6723.65   6723.30   6723.68     28.09      1.46    343.00     94.33
*  165.000     35.00       .00       .00   6723.00   1000.00   6723.92   6723.48   6723.98     34.24      2.05    491.25    170.90
*  165.000     35.00       .00       .00   6723.00   5000.00   6725.14   6724.39   6725.43     48.64      4.31   1175.18    716.93
*  165.000     35.00       .00       .00   6723.00  10000.00   6726.13   6725.20   6726.65     54.26      5.85   1739.89   1357.59
*  165.000     35.00       .00       .00   6723.00  15000.00   6726.92   6725.87   6727.65     56.99      6.96   2202.71   1987.02
*  165.000     35.00       .00       .00   6723.00  20000.00   6727.61   6726.47   6728.53     57.93      7.83   2621.57   2627.72
*  165.000     35.00       .00       .00   6723.00  27300.00   6728.50   6727.26   6729.69     58.65      8.87   3173.59   3564.63

*  150.000     15.00       .00       .00   6720.00    100.00   6723.30   6720.19   6723.30       .03       .09   1152.52    605.82
*  150.000     15.00       .00       .00   6720.00    500.00   6723.68   6720.53   6723.68       .35       .35   1416.67    851.02
*  150.000     15.00       .00       .00   6720.00   1000.00   6723.98   6720.82   6723.99       .88       .62   1623.92   1065.11
*  150.000     15.00       .00       .00   6720.00   5000.00   6725.41   6722.17   6725.47      4.59      1.91   2622.44   2332.70
*  150.000     15.00       .00       .00   6720.00  10000.00   6726.58   6723.48   6726.71      7.49      2.89   3457.93   3654.80
*  150.000     15.00       .00       .00   6720.00  15000.00   6727.53   6724.05   6727.73      9.39      3.62   4144.64   4896.16
*  150.000     15.00       .00       .00   6720.00  20000.00   6728.36   6724.57   6728.63     10.77      4.21   4749.98   6095.23
*  150.000     15.00       .00       .00   6720.00  27300.00   6729.43   6725.27   6729.80     12.22      4.92   5546.06   7809.33

*  100.000     50.00       .00       .00   6711.00    100.00   6723.30   6712.19   6723.30       .00       .03   3215.31   2914.50
*  100.000     50.00       .00       .00   6711.00    500.00   6723.68   6713.27   6723.68       .02       .14   3539.67   3419.45
*  100.000     50.00       .00       .00   6711.00   1000.00   6723.99   6714.00   6723.99       .07       .26   3799.11   3845.90
*  100.000     50.00       .00       .00   6711.00   5000.00   6725.46   6716.70   6725.48       .66       .99   5049.42   6166.71
*  100.000     50.00       .00       .00   6711.00  10000.00   6726.69   6718.71   6726.73      1.41      1.64   6096.63   8426.65
*  100.000     50.00       .00       .00   6711.00  15000.00   6727.69   6719.96   6727.77      2.05      2.16   6952.53  10472.65
*  100.000     50.00       .00       .00   6711.00  20000.00   6728.57   6720.84   6728.67      2.60      2.61   7700.40  12399.31
*  100.000     50.00       .00       .00   6711.00  27300.00   6729.70   6721.75   6729.85      3.27      3.16   8674.50  15094.38
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      SECNO     XLCH     ELTRD     ELLC     ELMIN        Q      CWSEL     CRIWS        EG     10*KS       VCH      AREA      .01K

*    50.000    50.00       .00      .00   6705.00    100.00   6723.30   6706.40   6723.30       .00       .02   5238.93   6368.39
*    50.000    50.00       .00      .00   6705.00    500.00   6723.68   6707.68   6723.68       .01       .09   5577.06   7059.63
*    50.000    50.00       .00      .00   6705.00   1000.00   6723.99   6708.53   6723.99       .02       .17   5849.31   7635.98
*    50.000    50.00       .00      .00   6705.00   5000.00   6725.47   6711.73   6725.48       .22       .70   7161.81  10651.33
*    50.000    50.00       .00      .00   6705.00  10000.00   6726.72   6714.03   6726.74       .55      1.21   8269.31  13484.02
*    50.000    50.00       .00      .00   6705.00  15000.00   6727.73   6715.62   6727.78       .88      1.63   9177.41  15991.48
*    50.000    50.00       .00      .00   6705.00  20000.00   6728.62   6716.79   6728.68      1.19      2.01   9974.10  18321.89
*    50.000    50.00       .00      .00   6705.00  27300.00   6729.77   6718.15   6729.87      1.61      2.48  11012.88  21535.94
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 HKM ASSOCIATES - 4/88

SUMMARY PRINTOUT TABLE  150

      SECNO         Q       CWSEL    DIFWSP    DIFWSX    DIFKWS    TOFWID     XLCH

*   1140.000    100.00    6700.89       .00       .00    -14.11     76.74      .00
*   1140.000    500.00    6701.62       .72       .00    -13.38     89.25      .00
*   1140.000   1000.00    6702.23       .62       .00    -12.77     99.93      .00
*   1140.000   5000.00    6705.03      2.80       .00     -9.97    148.25      .00
*   1140.000  10000.00    6707.16      2.13       .00     -7.84    184.97      .00
*   1140.000  15000.00    6708.79      1.62       .00     -6.21    213.01      .00
*   1140.000  20000.00    6710.08      1.30       .00     -4.92    235.42      .00
*   1140.000  27300.00    6711.71      1.62       .00     -3.29    263.41      .00

*   1050.000    100.00    6701.63       .00       .74       .00     77.81    90.00
*   1050.000    500.00    6702.68      1.06      1.07       .00     87.73    90.00
*   1050.000   1000.00    6703.45       .77      1.22       .00     95.03    90.00
    1050.000   5000.00    6706.29      2.84      1.26       .00    121.84    90.00
*   1050.000  10000.00    6708.12      1.82       .95       .00    139.01    90.00
    1050.000  15000.00    6712.49      4.37      2.23       .00    180.28    90.00
    1050.000  20000.00    6714.53      2.04      2.59       .00    199.49    90.00
    1050.000  27300.00    6717.04      2.52      2.99       .00    224.02    90.00

     972.000    100.00    6701.83       .00       .21       .00     76.36    78.00
     972.000    500.00    6702.99      1.16       .31       .00     83.87    78.00
     972.000   1000.00    6703.83       .85       .38       .00     89.32    78.00
     972.000   5000.00    6707.13      3.30       .84       .00    110.68    78.00
     972.000  10000.00    6710.91      3.78      2.13       .00    135.16    78.00
     972.000  15000.00    6713.38      2.47      1.62       .00    151.12    78.00
     972.000  20000.00    6715.54      2.16      2.10       .00    166.05    78.00
     972.000  27300.00    6718.95      3.41       .74       .00    205.43    78.00

*    850.000    100.00    6705.01       .00      3.18       .00     68.83   122.00
*    850.000    500.00    6705.79       .78      2.80       .00     74.17   122.00
     850.000   1000.00    6706.46       .67      2.13       .00     78.80   122.00
     850.000   5000.00    6709.71      3.25      2.23       .00    101.17   122.00
     850.000  10000.00    6712.32      2.61      1.33       .00    119.17   122.00
     850.000  15000.00    6714.35      2.03      1.32       .00    133.15   122.00
     850.000  20000.00    6716.11      1.76       .60       .00    145.27   122.00
     850.000  27300.00    6718.25      2.14     -1.07       .00    160.01   122.00

     750.000    100.00    6707.81       .00      2.80       .00     81.98   100.00
*    750.000    500.00    6708.47       .66      2.69       .00     89.87   100.00
*    750.000   1000.00    6709.07       .60      2.61       .00     97.05   100.00
*    750.000   5000.00    6711.91      2.83      2.20       .00    131.12   100.00
     750.000  10000.00    6714.13      2.23      -.05       .00    157.91   100.00
     750.000  15000.00    6716.63      2.49      -.02       .00    185.28   100.00
     750.000  20000.00    6718.73      2.11      -.04       .00    207.35   100.00
     750.000  27300.00    6721.43      2.69      -.07       .00    235.53   100.00
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      SECNO         Q       CWSEL    DIFWSP    DIFWSX    DIFKWS    TOFWID      XLCH

     650.000    100.00    6710.52      .00      2.70       .00    106.02    100.00
*    650.000    500.00    6711.09      .57      2.62       .00    111.40    100.00
*    650.000   1000.00    6711.59      .51      2.52       .00    116.18    100.00
*    650.000   5000.00    6714.11     2.51      2.20       .00    139.67    100.00
*    650.000  10000.00    6716.18     2.07      2.04       .00    153.89    100.00
     650.000  15000.00    6717.89     1.71      1.02       .00    165.65    100.00
     650.000  20000.00    6719.35     1.46       .52       .00    175.70    100.00
     650.000  27300.00    6721.19     1.84      -.28       .00    188.32    100.00

*    600.000    100.00    6712.26      .00      1.74       .00    136.62     50.00
*    600.000    500.00    6712.75      .49      1.66       .00    139.74     50.00
*    600.000   1000.00    6713.19      .44      1.59       .00    142.51     50.00
*    600.000   5000.00    6715.40     2.22      1.29       .00    156.54     50.00
*    600.000  10000.00    6717.32     1.92      1.14       .00    168.68     50.00
*    600.000  15000.00    6718.88     1.56       .99       .00    178.55     50.00
*    600.000  20000.00    6720.25     1.37       .90       .00    187.23     50.00
*    600.000  27300.00    6722.01     1.77       .83       .00    198.41     50.00

*    480.000    100.00    6715.24      .00      2.98       .00    223.45    120.00
     480.000    500.00    6715.60      .36      2.85       .00    225.63    120.00
     480.000   1000.00    6715.91      .31      2.72       .00    227.47    120.00
     480.000   5000.00    6717.47     1.56       .70       .00    236.86    120.00
     480.000  10000.00    6719.38     1.91       .27       .00    248.31    120.00
     480.000  15000.00    6721.32     1.94       .17       .00    259.96    120.00
     480.000  20000.00    6723.09     1.77       .21       .00    270.64    120.00
     480.000  27300.00    6725.34     2.25       .23       .00    286.32    120.00

*    250.000    100.00    6721.91      .00      6.67       .00    497.57    240.00
*    250.000    500.00    6722.12      .21      6.52       .00    498.63    240.00
*    250.000   1000.00    6722.30      .18      6.39       .00    499.55    240.00
*    250.000   5000.00    6723.26      .96      5.79       .00    504.48    240.00
*    250.000  10000.00    6724.11      .85      4.73       .00    508.81    240.00
*    250.000  15000.00    6724.83      .72      3.51       .00    512.52    240.00
*    250.000  20000.00    6725.46      .63      2.37       .00    515.74    240.00
*    250.000  27300.00    6726.71     1.25      1.36       .00    522.12    240.00

*    200.000    100.00    6723.14      .00      1.23       .00    532.50     50.00
     200.000    500.00    6723.37      .22      1.25       .00    536.21     50.00
     200.000   1000.00    6723.55      .18      1.25       .00    539.26     50.00
*    200.000   5000.00    6724.40      .85      1.14       .00    553.59     50.00
*    200.000  10000.00    6725.21      .81      1.10       .00    567.26     50.00
*    200.000  15000.00    6725.88      .68      1.05       .00    578.69     50.00
*    200.000  20000.00    6726.48      .60      1.02       .00    588.84     50.00
*    200.000  27300.00    6727.26      .77       .55       .00    601.91     50.00
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      SECNO          Q       CWSEL     DIFWSP     DIFWSX     DIFKWS     TOFWID      XLCH

*    165.000     100.00    6723.29       .00        .15        .00     534.90     35.00
*    165.000     500.00    6723.65       .35        .28        .00     540.82     35.00
*    165.000    1000.00    6723.92       .27        .36        .00     545.44     35.00
*    165.000    5000.00    6725.14      1.23        .75        .00     566.23     35.00
*    165.000   10000.00    6726.13       .98        .92        .00     582.83     35.00
*    165.000   15000.00    6726.92       .79       1.03        .00     596.10     35.00
*    165.000   20000.00    6727.61       .69       1.13        .00     607.85     35.00
*    165.000   27300.00    6728.50       .90       1.25        .00     623.01     35.00

*    150.000     100.00    6723.30       .00        .01        .00     684.45     15.00
*    150.000     500.00    6723.68       .38        .04        .00     688.56     15.00
*    150.000    1000.00    6723.98       .30        .07        .00     691.76     15.00
*    150.000    5000.00    6725.41      1.43        .27        .00     707.00     15.00
*    150.000   10000.00    6726.58      1.17        .46        .00     719.50     15.00
*    150.000   15000.00    6727.53       .95        .61        .00     729.61     15.00
*    150.000   20000.00    6728.36       .83        .75        .00     738.41     15.00
*    150.000   27300.00    6729.43      1.07        .92        .00     749.83     15.00

*    100.000     100.00    6723.30       .00        .00        .00     844.63     50.00
*    100.000     500.00    6723.68       .38        .00        .00     845.66     50.00
*    100.000    1000.00    6723.99       .31        .01        .00     846.48     50.00
*    100.000    5000.00    6725.46      1.47        .05        .00     850.43     50.00
*    100.000   10000.00    6726.69      1.23        .11        .00     853.73     50.00
*    100.000   15000.00    6727.69      1.00        .16        .00     856.41     50.00
*    100.000   20000.00    6728.57       .87        .21        .00     858.75     50.00
*    100.000   27300.00    6729.70      1.13        .27        .00     861.79     50.00

*     50.000     100.00    6723.30       .00        .00        .00     880.34     50.00
*     50.000     500.00    6723.68       .38        .00        .00     881.69     50.00
*     50.000    1000.00    6723.99       .31        .00        .00     882.77     50.00
*     50.000    5000.00    6725.47      1.48        .01        .00     887.98     50.00
*     50.000   10000.00    6726.72      1.24        .02        .00     892.35     50.00
*     50.000   15000.00    6727.73      1.02        .04        .00     895.92     50.00
*     50.000   20000.00    6728.62       .89        .06        .00     899.04     50.00
*     50.000   27300.00    6729.77      1.15        .08        .00     903.09     50.00
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 SUMMARY OF ERRORS AND SPECIAL NOTES


CAUTION SECNO=   1140.000  PROFILE=  1  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   1140.000  PROFILE=  2  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   1140.000  PROFILE=  3  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   1140.000  PROFILE=  4  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   1140.000  PROFILE=  5  CRITICAL DEPTH ASSUMED
CAUTION SECNO=   1140.000  PROFILE=  6  CRITICAL DEPTH ASSUMED
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CAUTION SECNO=    650.000  PROFILE=  3  MINIMUM SPECIFIC ENERGY
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```

APPENDIX H

APPENDIX H-1
ROADWAY ALIGNMENT DESIGN

APPENDIX H-1

ROADWAY ALIGNMENT DESIGN

The proposed roadway alignment and typical sections to be used in conjunction with the Middle Creek Dam project are presented herein.

Raising the crest of the dam causes the road to be too steep if the present alignment were followed. Therefore, the new road will follow the alignment of the auxiliary spillway to provide more acceptable grades.

A minimum radius of 200 feet is anticipated for all curves except at both ends of the dam, where alignment constraints require shorter radius curves. The alignment is shown on the plans.

The new roadway alignment will begin approximately 600 feet northwesterly of the existing west abutment of the dam. This point is designated Sta. 104+12.06. From this point the alignment will proceed southerly and follow a 200' radius curve to the right. It will then continue up the auxiliary spillway curving to the left along a compound curve with an initial radius of 375' followed by a radius of 200'. The approach to the day use area is located near Sta. 115+00. At Sta. 116+10 the alignment curves to the right on a 100' radius to the earth reinforced structure wall section. This curve will require a 31-foot top width to allow two logging trucks to pass on the curve.

Across the dam, the road follows the existing general alignment. East of the section of earth reinforced structure the road curves to the right on a 450' radius followed by a 150' radius curve to the left as it approaches the principal spillway. Immediately east of the spillway, the alignment curves right on a 100' radius curve to match the existing road along the easterly side of the reservoir. Immediately east of bridge an intersecting road requires a "yield" sign.

The radius, superelevation rate or crown, and typical sections proposed, are shown on Sheet 33 of the plans (Appendix A-1).

APPENDIX H-2
GUARDRAIL WARRANT ANALYSIS

APPENDIX H-2
GUARDRAIL WARRANT ANALYSIS

The proposed roadway alignment for the Middle Creek Dam project was analyzed to determine the need for guardrails due to the high embankment slopes, rip rap slopes, and presence of water adjacent to the roadway on the upstream side of the dam. Guardrail warrants are usually based on an evaluation of the relative hazard of the barrier versus the unshielded hazard. A traffic barrier should only be installed if it reduces the severity of potential accidents.

The report "Guide for Selecting, Locating, and Designing Traffic Barriers", AASHTO, 1977, was used for this analysis. The roadway in the project area is estimated to have an average daily traffic volume of less than 400 vehicles per day. The design speed of the roadway in this area is 20 mph. Therefore, the cost effective selection procedure presented in Chapter VII of the report was felt to be appropriate for this project.

The reinforced earth wall section and the structure over the principal spillway are not included in this analysis. Traffic barriers are definitely warranted across these structures. The two roadside hazard areas requiring analysis are the embankment slopes on the downstream face and on the upstream face of the dam.

The analysis indicates that guardrail would not be cost effective on the downstream face of the dam embankment section. However, guardrail would be cost effective on the upstream slope. It is therefore recommended that metal guardrail be installed at the following approximate locations:

Station 115+50 to 117+00, RT
Station 126+50 to 134+00, RT

It is recommended that the new metal guardrail be tied to the traffic barriers which will be installed across the reinforced earth wall section and the bridge across the principal spillway. The guardrail should be located in accordance with the criteria specified in the AASHTO guide.

APPENDIX I

APPENDIX I-1

PRINCIPAL SPILLWAY BRIDGES TYPICAL SECTION AND DESIGN PARAMETERS

APPENDIX I-1
PRINCIPAL SPILLWAY BRIDGES
TYPICAL SECTION AND DESIGN PARAMETERS

As part of the rehabilitation of Middle Creek Dam, new bridges are required across the principal spillway. The bridges will consists of a new pedestrian bridge and a new vehicle bridge. The vehicle bridge is intended to replace the existing bridge which is being removed to facilitate raising the top of the dam approximately 8 feet. The pedestrian bridge is a new structure being added upstream of the vehicle bridge to accommodate foot traffic across the dam.

This report is to present the design parameters being used for the bridges and the typical cross section anticipated.

DESIGN LOADS

Two design live loads for the vehicle bridge will be considered. The first will consist of an HS20-44 truck load as defined in Section 3.7 of "Standard Specifications for Highway Bridges" published by the American Association of State Highway and Transportation Officials (AASHTO). The second live load to be considered is an 80,000 pound log truck. The dimensions and axle loads for both load cases are shown on the attached Sketch No. 1. The bridge will be designed for the load case which produces the maximum stress condition.

The pedestrian bridge will be designed for a snow load of 135 psf. This load was established using the Montana State University publication titled "Recommended Snow Loads for

Montana Structures". This snow load is larger than the pedestrian load of 85 psf which is required by Article 3.14.1.3 of AASHTO "Standard Specifications for Highway Bridges".

The vehicle bridge traffic rail and the pedestrian bridge hand rail will be designed according to Article 2.7 AASHTO "Standard Specifications for Highway Bridges. The bridge traffic rail is anticipated to be a precast concrete barrier rail system (see attached Sketch No. 3). The pedestrian bridge hand rail will be a steel pipe system attached to the top of the bridge deck.

MATERIALS AND CROSS SECTION

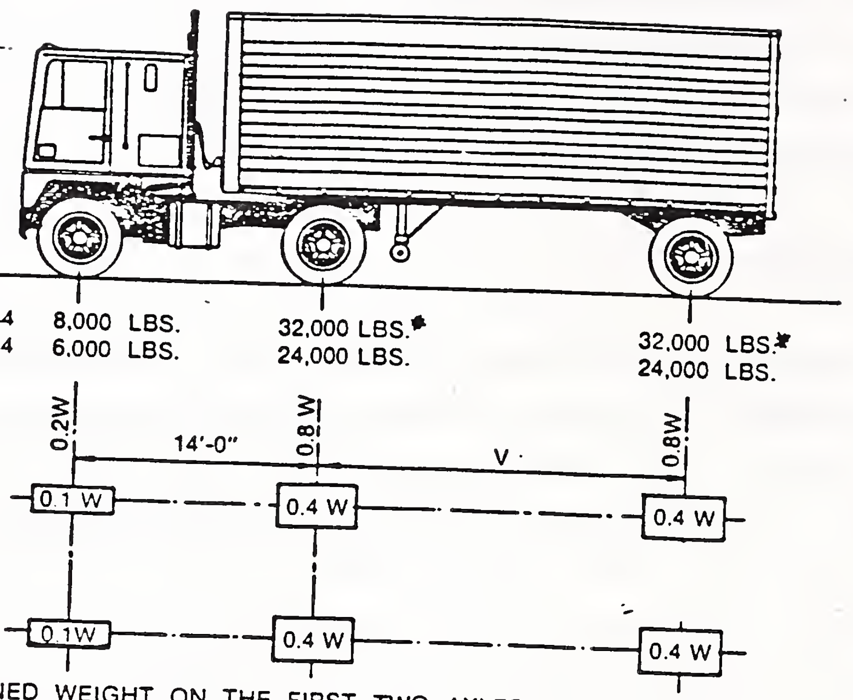
Both the bridges are anticipated to be constructed of precast prestressed concrete channel sections (see attached sketch No. 2). Previous experience with vehicle bridges has revealed that the least expensive bridge systems typically has been precast concrete sections that provide an integral deck. Locally available beams consist of Channel Beams, Bulb Tee's and a Triple Leg Tee Section. The width of the spillway and the on-site concrete forming to embed the beams into the spillway walls are parameters that indicate the Channel Beams are the best system for this application. The sections proposed will have an integral deck and when joined together, the intermediate joints will be grouted full. The bridge should provide an adequate riding surface for a road across the dam.

A study was undertaken to evaluate various pedestrian bridge options. Based on least cost, long term maintenance requirements and compatibility with other aspects of this project a precast, prestressed concrete channel system was selected for the pedestrian bridge. The vehicle bridges and pedestrian bridge are anticipated to be installed adjacent to each other as shown on the attached sketch No. 2. The pedestrian bridge will be designed to set on the flared walls at the spillway inlet. The span length at the center of the pedestrian bridge is anticipated to be approximately 43½ feet. The superstructure cost is estimated to be $10,600.00 or approximately $244.00 per lineal foot.

CONCLUSIONS

Based upon cost, maintenance, and simplicity the precast channel beam concrete bridge system proposed appears to be the best choice for construction of the two principal spillway bridges. The bridge system will bear directly on the spillway walls and will be coordinated with the road alignment and spillway.

CASE — I
AASHTO HS-20


HS20-44
HS15-44
8,000 LBS.
6,000 LBS.
32,000 LBS.*
24,000 LBS.
32,000 LBS.*
24,000 LBS.
0.2W
14'-0"
0.8 W
V
0.8W
0.1 W
0.4 W
0.4 W
0.1W
0.4 W
0.4 W

W = COMBINED WEIGHT ON THE FIRST TWO AXLES WHICH IS THE SAME AS FOR THE CORRESPONDING H (M) TRUCK.
V = VARIABLE SPACING — 14 FEET TO 30 FEET INCLUSIVE. SPACING TO BE USED IS THAT WHICH PRODUCES MAXIMUM STRESSES.

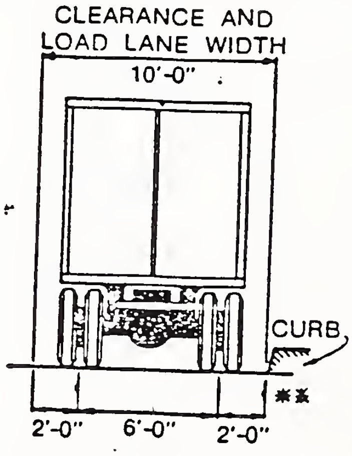
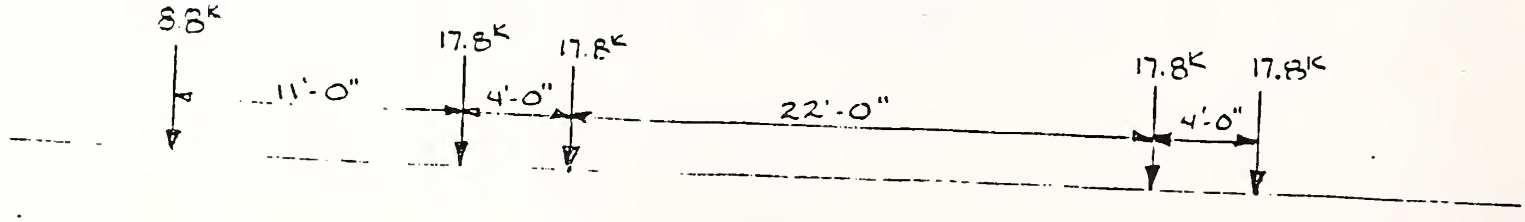

CLEARANCE AND
LOAD LANE WIDTH
10'-0"
CURB
**
2'-0"
6'-0"
2'-0"

Figure 3.7.7A. Standard HS Trucks

*In the design of timber floors and orthotropic steel decks (excluding transverse beams) for HS 20 loading, one axle load of 24,000 pounds or two axle loads of 16,000 pounds each, spaced 4 feet apart may be used, whichever produces the greater stress, instead of the 32,000-pound axle shown.

**For slab design, the center line of wheels shall be assumed to be 1 foot from face of curb. (See Article 3.24.2).

CASE II
80,000 lb LOG TRUCK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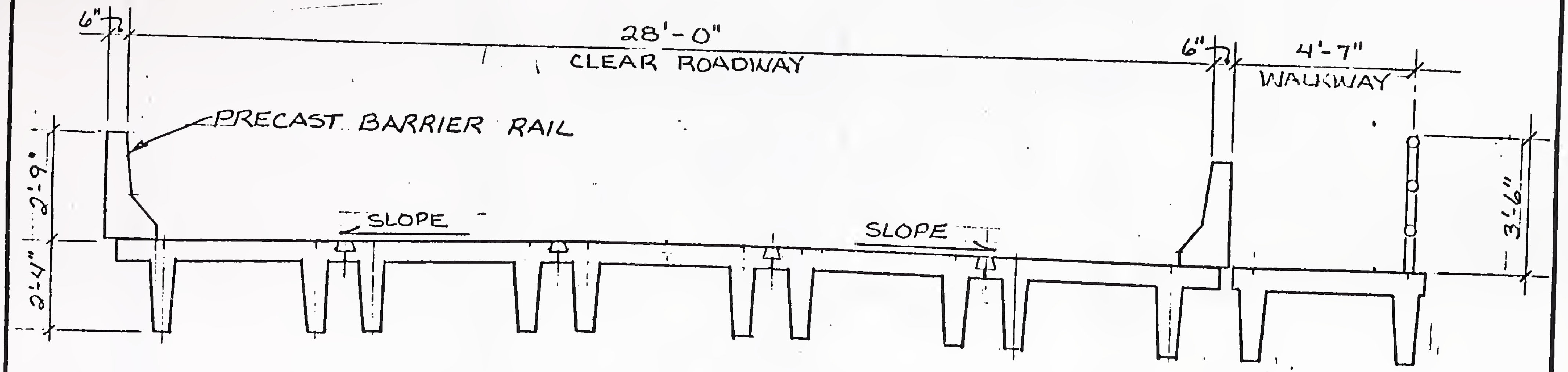
11'-0"
17.8K
4'-0"
17.8K
22'-0"
17.8K
4'-0"
17.8K

SKETCH No. 1

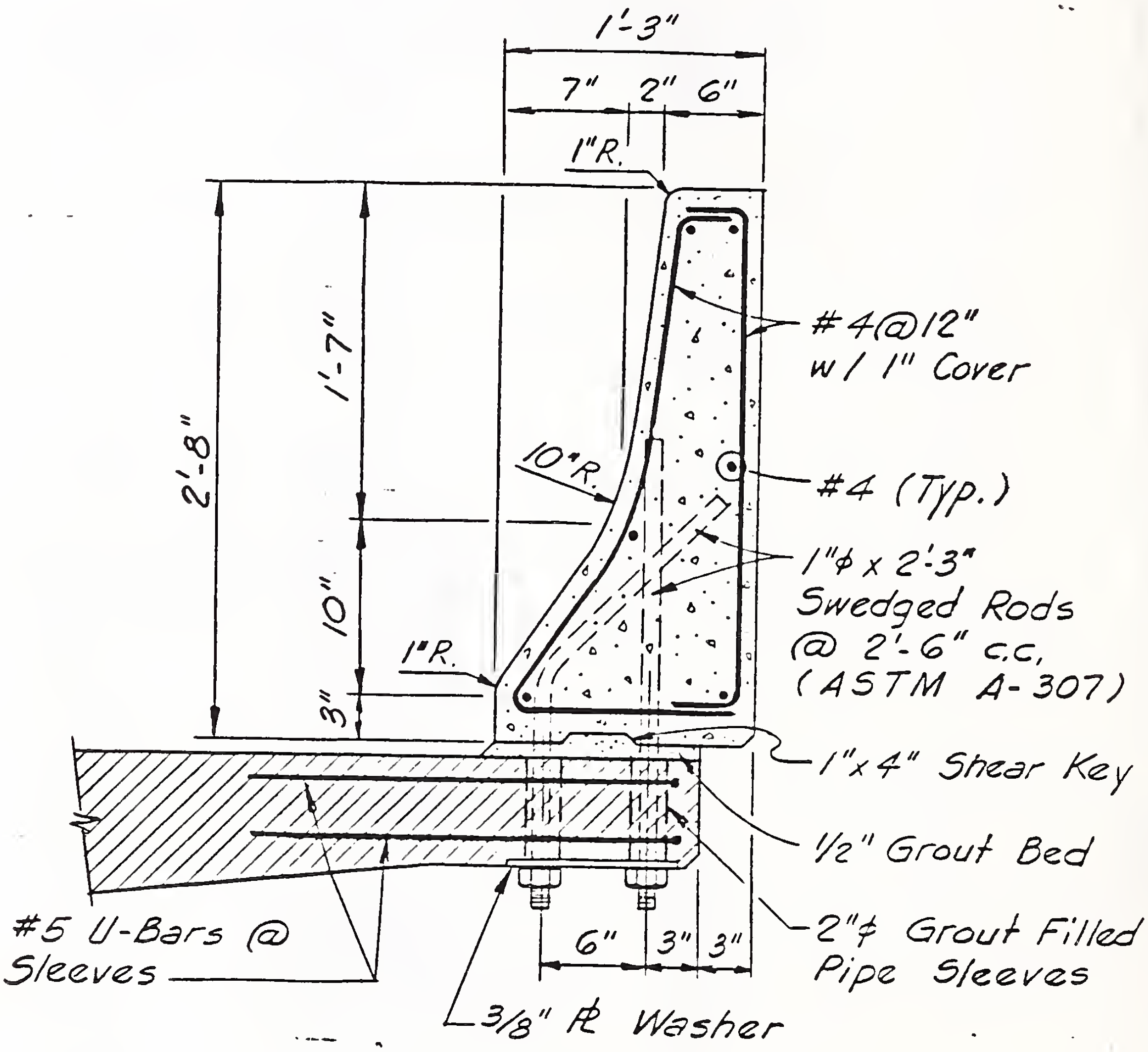

6"
28'-0"
CLEAR ROADWAY
6"
4'-7"
WALKWAY
PRECAST BARRIER RAIL
2'-9"
2'-4"
SLOPE
SLOPE
3'-6"

BRIDGE SECTION

1/4" = 1'-0"

SKETCH No. 2

HKM ASSOCIATES
ENGINEERS · PLANNERS


1'-3"
7"
2"
6"
1"R.
2'-8"
1'-7"
10"
3"
10"R.
1"R.
#4@12"
w/ 1" Cover
#4 (Typ.)
1"ϕ x 2'-3"
Swedged Rods
@ 2'-6" c.c.
(ASTM A-307)
1"x 4" Shear Key
1/2" Grout Bed
2"ϕ Grout Filled
Pipe Sleeves
6"
3"
3"
#5 U-Bars @
Sleeves
3/8" ℙ Washer

BARRIER RAIL DETAIL

1" = 1'-0"

SKETCH No. 3

APPENDIX I-2

FOOT BRIDGE ALTERNATIVE COMPARISON

APPENDIX I-2

FOOT BRIDGE ALTERNATIVE COMPARISON

As part of the rehabilitation of Middle Creek Dam a new pedestrian bridge is required across the principal spillway upstream of the highway bridge. HKM investigated various bridge configurations and prepared construction cost estimates. This report is a presentation of the various alternatives investigated including the associated cost estimates and a recommendation.

The bridge systems investigated consist of the following:

1. Precast, Prestressed Concrete
2. Glulam Stringers with Timber Deck
3. Steel Truss with Timber Deck
4. Steel Beams with Timber Deck

Each bridge is to be installed upstream of the highway bridge on the flared inlet section of the spillway. The bridge bearing was set so that the lowest portion of the pedestrian bridge was equal to the lowest portion of the highway bridge. Each Bridge was designed to a level sufficient to obtain major component sizes for cost estimating. The bridges were designed to support a uniform live load of 85 psf on a four foot walkway. The snow load is 135 psf.

Following is a brief description of each and a discussion of the expected maintenance. Attached is a sketch for each and a preliminary construction cost estimate.

PRECAST PRESTRESSED CONCRETE BRIDGE

This bridge is to be constructed of a precast prestressed double tee section (see attached Sketch No. 1). This section is the same section as that anticipated for the highway bridge. The handrail will be a steel pipe rail attached to the concrete section by grouting the posts into inserts cast into the top of the concrete deck.

This bridge will have very little maintenance except that associated with the handrail. The concrete section will be left bare and will provide a durable, relatively vandal proof system. The handrails can be hot dip galvanized or painted with a cold galvanizing compound to reduce the maintenance as much as possible.

This bridge system can be adapted to fit the flared side walls and can be reinforced to carry heavy loads for little additional cost. This bridge will blend in well with the spillway improvements and will match the highway bridge.

Cost Estimate

Precast Concrete Section	53 L.F. @ $130.00	=	$ 6,890.00
Steel Handrail	60 L.F. @ $39.00	=	2,340.00
	SUBTOTAL		$ 9,230.00
	PLUS 15% CONTINGENCY		1,385.00
			$10,615.00
	SAY $10,600.00		

GLULAM STRINGER BRIDGE WITH TIMBER DECK

This bridge is to be constructed with two glue laminated timber beams connected with steel beams supporting a timber floor system (see Sketch No. 2). A steel handrail will be connected to the steel floor beams and extend up the inside of the glulam beams. The timber floor and glulam beams will be pressure treated but they will required consistent maintenance. A totally wood structure also lends to vandalism by name carving and other destruction.

This bridge could be built to accommodate the flared spillway walls. The glulam beams can be obtained from local suppliers and would not require any specialized equipment. Some care during construction will be necessary to not mar the treated surface.

Cost Estimate

Glulam Beams	1900 B.F. x $3.00/B.F. =	$ 5,700.00
Timber Floor	690 B.F. x $1.40/B.F. =	966.00
Steel Rail & Floor Beams	2650 lbs. x $2.00/lb =	5,300.00
	SUBTOTAL	$11,966.00
	PLUS 15% CONTINGENCY	1,795.00
		$13,761.00
	SAY $13,800.00	

STEEL TRUSS BRIDGE WITH TIMBER DECK

This bridge is to be constructed of two structural steel trusses with a timber floor supported between them (see attached Sketch No. 3). This bridge could be built locally by a steel fabricator or it could be a prefabricated bridge such as the town and country bridge as manufactured by Continental Manufacturing Inc., Alexandria, Minnesota. This bridge could be painted or constructed of self-weathering steel to reduce long term maintenance. The flooring would be pressure treated timber.

A self weathering steel bridge will have very little maintenance. It should be recognized however, that this type of steel will cause rust stains to occur wherever the water dripping off the bridge will drip or run on the concrete. With the bridge spanning over the spillway there will be considerable discoloring of the concrete. A painted structure will have some long term maintenance to keep up the protective paint coating.

The premanufactured bridge typically comes with square ends and would have a special foundation system or a locally fabricated bridge could be built to accommodate the flared inlet side walls.

Cost Estimate

Structural Steel	4800 lbs x $2.00/lb =	$ 9,600.00
Timber Flooring	690 B.F. x $1.40/B.F. =	966.00
	SUBTOTAL	$10,566.00
	PLUS 15% CONTINGENCY	1,585.00
		$12,151.00
	SAY $12,200.00	

STEEL BEAM BRIDGE WITH TIMBER DECK

This bridge is to be constructed of two structural steel, wide flange beams. The beams would be connected with transverse floor beams which in turn would support treated timber stringers and treated timber deck. A steel handrail would be connected to the top flange of the steel beams (see attached Sketch No. 4).

This bridge could be built of self-weathering or painted steel. The maintenance for this bridge would be similar to the steel truss structure. Discoloring of the concrete can be expected with the self-weathering steel.

This bridge would be fabricated locally to accommodate the flared side walls of the spillway inlet.

Cost Estimate

Structural Steel	4000 lbs x $2.00 =	$ 8,000.00
Timber Floor	690 B.F. x $1.40/B.F. =	966.00
Handrail	120 L.F. x $39.00 =	4,680.00
	SUBTOTAL	$13,646.00
	PLUS 15% CONTINGENCY	2,047.00
		$15,693.00
	SAY $15,700.00	

RECOMMENDATION

The total cost of the bridge varies from $10,600 to $15,700. The unit costs between $50 and $74 per square foot of area. This cost was compared with a glulam bridge built across the Boulder River above Big Timber in 1979. The Boulder River Bridge was built for approximately $45.00 per square foot. Additionally some U.S. Forest Service trail bridge costs were reviewed and found to be $50.00 per square foot for a slab bridge, $85.00 per square foot for an open web joist bridge with back country installation and $60.00 per square foot for a town and country continental custom bridge. As can be seen the estimated costs seem reasonable.

There are various maintenance requirements for each as discussed earlier and other factors such as discoloration of the adjacent concrete and vandalism. Comparing the cost, maintenance, vandalism potential and the simplicity, the precast concrete bridge appears to have a distinct advantage. It will also match the highway bridge and is the least costly alternative. Additionally this bridge can be made to carry much heavier loads than the others for the same cost. The reinforcing required in the section for heavier loads is incidental compared to the other costs. This bridge can also be set immediately adjacent to the highway bridge to serve more as a sidewalk than a separate bridge. For the reasons stated above the precast concrete section is being recommended for construction of the foot bridge over the principal spillway.

APPENDIX J

APPENDIX J-1
GRAYLING SPAWNING MITIGATION STRUCTURE

APPENDIX J-1

GRAYLING SPAWNING MITIGATION STRUCTURE

SUMMARY

A simple log structure has been proposed to allow for operation of a side channel of the West Fork of Hyalite Creek to replace Arctic Grayling spawning grounds that would be lost after raising Middle Creek Dam. The results of this hydrologic and hydraulic analysis indicate a structure of the type proposed can meet the objectives required in a cost effective and visually acceptable manner. Other structures, such as a gated diversion dam, were considered but were ruled out because of design problems.

PURPOSE

Spawning studies performed during 1986 and 1987 indicated that Grayling spawning areas would be inundated if the normal water surface of Middle Creek Dam is raised 10 feet. It is possible the grayling may spawn in existing sections of the West Fork of Hyalite Creek after the dam is raised. However, it is the opinion of the fishery biologists (both working for the DNRC and the USFS) that new areas must be developed to insure successful spawning and that a side channel located immediately upstream of the proposed pool offers the best possibilities. This side channel is currently blocked at its upstream end so that water only flows in the side channel during periods of high runoff or when an ice dam forms raising the water level in the creek above its banks.

The purpose of this structure is to provide water to the side channel at the time and in the amounts required to support spawning and hatching of fry. The 1986 and 1987 spawning studies provide suitability index curves for Grayling spawning. In order to insure the proper depths and velocities for spawning, it was necessary to survey the creek and side channel, analyze the hydrology of the creek, and hydraulically route the anticipated flows through the creek and side channel using proposed designs.

SURVEY

The West Fork of Hyalite Creek and the adjacent side channel were surveyed in November 1987. Cross-sections of the creek and side channel were surveyed at 50 feet intervals (see Figures 1 and 2). Photographs were taken to aid in selection of roughness coefficients used in the hydraulic modeling. Bed samples from the side channel were also collected.

HYDROLOGY

A hydrologic analysis was performed to determine the range of flows that would be expected during spawning. It is anticipated that spawning will occur during a period shortly after the peak spring runoff, therefore, a statistical analysis of daily runoff peaks is required. This analysis indicates the magnitude of runoff that can be expected to be exceeded during a specified period of time. Daily peaks were obtained for the period 1975-1986. Mean June flows were obtained for the period of 1966-1986. This data provides additional information that can be used in determining whether individual years are above, below, or near average.

The following data for the West Fork Hyalite Creek streamgage was provided by the DNRC.

YEAR	MEAN JUNE (CFS)	DAILY MAX JUNE (CFS)
1966	84.3	
1967	152	
1968	141	
1969	101	
1970	---	
1971	97.8	
1972	113	
1973	114	
1974	168	
1975	139	240 (July 274)
1976	109	145 (July 162)
1977	93.0	154
1978	99.0	145
1979	116	171
1980	85.2	154
1981	102	160
1982	104	192
1983	109	168 (July 184)
1984	106	180
1985	58.0	126
1986	114	178
AVERAGE	110	

A flood flow frequency analysis was performed and the results are as follows:

FLOW IN CFS	EXCEEDANCE PROBABILITY	RECURRENCE INTERVAL IN YEARS
425	0.002	500
361	0.005	200
321	0.010	100
287	0.020	50
258	0.040	25
224	0.100	10
200	0.200	5
166	0.500	2
142	0.800	1.25
132	0.900	1.11
124	0.950	1.05
111	0.990	1.01

Four flow levels were selected for use in this analysis. A discharge of 321 cfs corresponds to the 100 year flood peak. A discharge of 240 cfs is the largest daily peak experienced during the years 1975-1986. A flow of 140 cfs approximates bank-full conditions. A streamflow of 82 cfs represents lower flow conditions. It is less than the daily peak that has an exceedance probability of 0.99 (111 cfs). It is approximately equal to the June mean discharge in 1966 and 1980, the only lower mean occurring in 1985 (58.0 cfs).

HYDRAULICS

The proposed diversion consists of opening the bank of the West Fork of Hyalite Creek at the upstream end of the side channel (Figures 1 and 2). Logs would be placed across the Creek and side channel entrance to prevent future degradation of the channel bottom. The use of log structures has been researched extensively and documented in submittals associated with construction of the log sill installed as a part of the 1987 spawning study. The proposed log diversion has the following advantages:

1. No operator required
2. Simple, inexpensive construction
3. Visually acceptable
4. Fish passage to upper reaches of the Creek unobstructed
5. Will not catch debris
6. Will not have ice problems
7. Will not create a large backwater (pond) upstream
8. Will not require continual maintenance
9. Major construction equipment not required in Creek

Water surface profiles through the creek and side channel were determined using the U.S. Army Corps of Engineers HEC2 computer program. Channel cross-sections were entered from the survey data. Roughness and expansion/contraction coefficients were estimated based on the photos and the field visit. Streamflows are from the hydrologic analysis. With subcritical flow, computations are performed working in an upstream direction. Computations were performed going upstream individually through the creek and the side channel. The ratio of flow in the creek and side channel was varied until the energy grade line at the upstream end of the side channel matched that of an adjacent location in the creek.

Water surface profiles were estimated representing 4 different flow levels: 321 cfs, 240 cfs, 140 cfs, and 82 cfs. Where water surface profiles exceed the maximum elevation of the surveyed cross sections, the HEC-2 model extends the right and left end points of the cross section vertically. This is conservative for this analysis because it concentrates flow in the channel that may have otherwise spread into the overbanks and/or island. This results in slightly higher channel velocities in the model than would actually occur. The results are shown on Figure 2 and the following tables.[2]

COMPARISON WITH ERODIBLE VELOCITIES

DAILY PEAK FLOW	CREEK	SIDE CHANNEL	MAXIMUM VELOCITY SIDE CHANNEL	NON-ERODIBLE VEL. (fps)[1]			COMPUTED VEL. (fps)		
(cfs)	(cfs)	(cfs)	(fps) (Sta.)	1+00	2+50	4+00 to 4+69	1+00	2+50	4+10
82	60	22	4.14(0+25)	3.9	4.3	3.2	3.08	1.90	0.95
140	96	44	3.90(1+00)	3.9	4.3	3.2	3.90	2.93	1.54
240	160	80	4.47(1+00)	3.9	4.3	3.2	4.47	4.01	2.17
321	210	111	4.96(1+00)	3.9	4.3	3.2	4.96	4.64	2.58

---

[1] Chow, 1959, Open-Channel Hydraulics, Fig. 7-3
Grain size from HKM samples, November 1987

[2] The results presented in this text represent a condition where the logs across the main channel and side channel are set at the same crest elevation. During final design the main channel log crest was raised 0.6 foot above the side channel log. Hydraulics in the side channel remain the same for a specified side channel flow. Only the distribution of flow between the main channel and side channel have changed. Figures 1 and 2 reflect the final design.

COMPARISON WITH SUITABILITY INDICES, Q=82CFS

STA	HABITAT UTILIZATION (1) 0.0(2) WIDTH (FT)	0.2(3) WIDTH (FT)	0.4(4) WIDTH (FT)	0.6(5) WIDTH (FT)	0.8(6) WIDTH (FT)	VEL (FPS)	HABITAT UTILIZATION (1) 0.0(2) AREA (SF)	0.2(3) AREA (SF)	0.4(4) AREA (SF)	0.6(5) AREA (SF)	0.8(6) AREA (SF)
0	7	7	7	7	0	1.83					
							93.75	93.75	93.75	93.75	0
15	5.5	5.5	5.5	5.5	0	1.89					
							27.5	27.5	27.5	27.5	0
25	0	0	0	0	0	4.14					
							0	0	0	0	0
50	0	0	0	0	0	2.39					
							0	0	0	0	0
100	0	0	0	0	0	3.08					
							120	120	120	0	0
150	4.8	4.8	4.8	0	0	1.68					
							120	120	120	0	0
200	0	0	0	0	0	2.25					
							147.5	147.5	147.5	147.5	0
250	5.9	5.9	5.9	5.9	0	1.9					
							147.5	147.5	147.5	147.5	0
300	0	0	0	0	0	2.64					
							235	235	235	0	0
350	9.4	9.4	9.4	0	0	1.51					
							372	282	282	0	0
410	3	0	0	0	0	0.95					
							134	0	0	0	0
450	3.7	0	0	0	0	1.14					
							152	0	0	0	0
469	12.3	0	0	0	0	0.45					
							1549.25	1173.25	1173.25	416.25	0

NOTES
(1) FERNET, ET. AL., 1987 HYALITE RESERVOIR ARCTIC GRAYLING STUDY, FIGURES 9 AND 10
DEPTH 1-1.5 FT, HABITAT UTIL 0.8 IN ALL CASES
(2) VELOCITY 0.2-4.6 FPS
(3) VELOCITY 1.2-4.0 FPS
(4) VELOCITY 1.5-3.7 FPS
(5) VELOCITY 1.8-3.4 FPS
(6) VELOCITY 2.0-3.1 FPS

COMPARISON WITH SUITABILITY INDICES, Q=140CFS

STA	HABITAT UTILIZATION (1) 0.0(2) WIDTH (FT)	0.2(3) WIDTH (FT)	0.4(4) WIDTH (FT)	0.6(5) WIDTH (FT)	0.8(6) WIDTH (FT)	VEL (FPS)	HABITAT UTILIZATION (1) 0.0(2) AREA (SF)	0.2(3) AREA (SF)	0.4(4) AREA (SF)	0.6(5) AREA (SF)	0.8(6) AREA (SF)
0	2.9	2.9	2.9	2.9	2.9	2.62					
							68.25	68.25	68.25	68.25	68.25
15	6.2	6.2	6.2	6.2	6.2	2.4					
							60.5	60.5	31	31	31
25	5.9	5.9	0	0	0	3.89					
							191.25	191.25	117.5	117.5	117.5
50	9.4	9.4	9.4	9.4	9.4	2.71					
							417.5	417.5	235	235	235
100	7.3	7.3	0	0	0	3.9					
							437.5	437.5	255	255	255
150	10.2	10.2	10.2	10.2	10.2	2.25					
							412.5	412.5	412.5	412.5	412.5
200	6.3	6.3	6.3	6.3	6.3	2.77					
							365	365	365	365	365
250	8.3	8.3	8.3	8.3	8.3	2.93					
							355	355	355	355	355
300	5.9	5.9	5.9	5.9	5.9	2.95					
							182.5	182.5	182.5	182.5	182.5
350	1.4	1.4	1.4	1.4	1.4	2.26					
							111	111	111	42	42
410	2.3	2.3	2.3	0	0	1.54					
							284	284	284	0	0
450	11.9	11.9	11.9	0	0	1.53					
							152	113.05	113.05	0	0
469	4.1	0	0	0	0	0.78					
							3037	2998.05	2529.8	2063.75	2063.75

NOTES
(1) FERNET, ET. AL., 1987 HYALITE RESERVOIR ARCTIC GRAYLING STUDY, FIGURES 9 AND 10
DEPTH 1-1.5 FT, HABITAT UTIL 0.8 IN ALL CASES
(2) VELOCITY 0.2-4.6 FPS
(3) VELOCITY 1.2-4.0 FPS
(4) VELOCITY 1.5-3.7 FPS
(5) VELOCITY 1.8-3.4 FPS
(6) VELOCITY 2.0-3.1 FPS

COMPARISON WITH SUITABILITY INDICES, Q=240CFS

STA	HABITAT UTILIZATION (1) 0.0(2) WIDTH (FT)	0.2(3) WIDTH (FT)	0.4(4) WIDTH (FT)	0.6(5) WIDTH (FT)	0.8(6) WIDTH (FT)	VEL (FPS)	HABITAT UTILIZATION (1) 0.0(2) AREA (SF)	0.2(3) AREA (SF)	0.4(4) AREA (SF)	0.6(5) AREA (SF)	0.8(6) AREA (SF)
0	2.9	2.9	0	0	0	3.74					
							58.5	58.5	36.75	36.75	0
15	4.9	4.9	4.9	4.9	0	3.22					
							57	24.5	24.5	24.5	0
25	6.5	0	0	0	0	4.31					
							148.75	67.5	67.5	67.5	67.5
50	5.4	5.4	5.4	5.4	5.4	3.06					
							187.5	135	135	135	135
100	2.1	0	0	0	0	4.47					
							162.5	110	110	110	110
150	4.4	4.4	4.4	4.4	4.4	2.81					
							357.5	357.5	357.5	357.5	110
200	9.9	9.9	9.9	9.9	0	3.2					
							305	247.5	247.5	247.5	0
250	2.3	0	0	0	0	4.01					
							260	202.5	202.5	202.5	0
300	8.1	8.1	8.1	8.1	0	3.19					
							237.5	237.5	237.5	237.5	35
350	1.4	1.4	1.4	1.4	1.4	3.01					
							111	111	111	111	111
410	2.3	2.3	2.3	2.3	2.3	2.17					
							284	284	284	46	46
450	11.9	11.9	11.9	0	0	1.78					
							117.8	113.05	113.05	0	0
469	0.5	0	0	0	0	1.13					
							2287.05	1948.55	1926.8	1575.75	614.5

NOTES
(1) FERNET, ET. AL., 1987 HYALITE RESERVOIR ARCTIC GRAYLING STUDY, FIGURES 9 AND 10
DEPTH 1-1.5 FT, HABITAT UTIL 0.8 IN ALL CASES
(2) VELOCITY 0.2-4.6 FPS
(3) VELOCITY 1.2-4.0 FPS
(4) VELOCITY 1.5-3.7 FPS
(5) VELOCITY 1.8-3.4 FPS
(6) VELOCITY 2.0-3.1 FPS

The tables indicate the number of square feet of spawning area that will be generated for flows of 82, 140, and 240 cfs. All identified spawning areas have depths of 1 - 1.5 feet (habitat utilization (HU) 0.8 or higher). The reported velocities are averages for the entire cross-section and it is known that velocity will vary across the section when field measured. Velocities in areas having depths of 1 - 1.5 feet were categorized into velocity ranges having HU values of 0.8 and above, 0.6 and above, 0.4 and above, 0.2 and above, and 0.0 and above.

For a discharge of 140 cfs, approximately 3000 square feet of spawning area can be expected with velocities having a HU 0.0 or higher. The area drops to about 2000 square feet using velocities having HU of 0.8 or higher. Velocities are non-erosive. A discharge of 140 cfs is approximately bank full and is the flow during the peak spawning period of 1986, an average runoff year.

For a flow of 82 cfs, approximately 1500 square feet of spawning area would be anticipated with velocities having a HU of 0.0 or greater. For velocities having HU of 0.6 or greater, the area drops to about 400 square feet. Erosive velocities are not a problem at this flow.

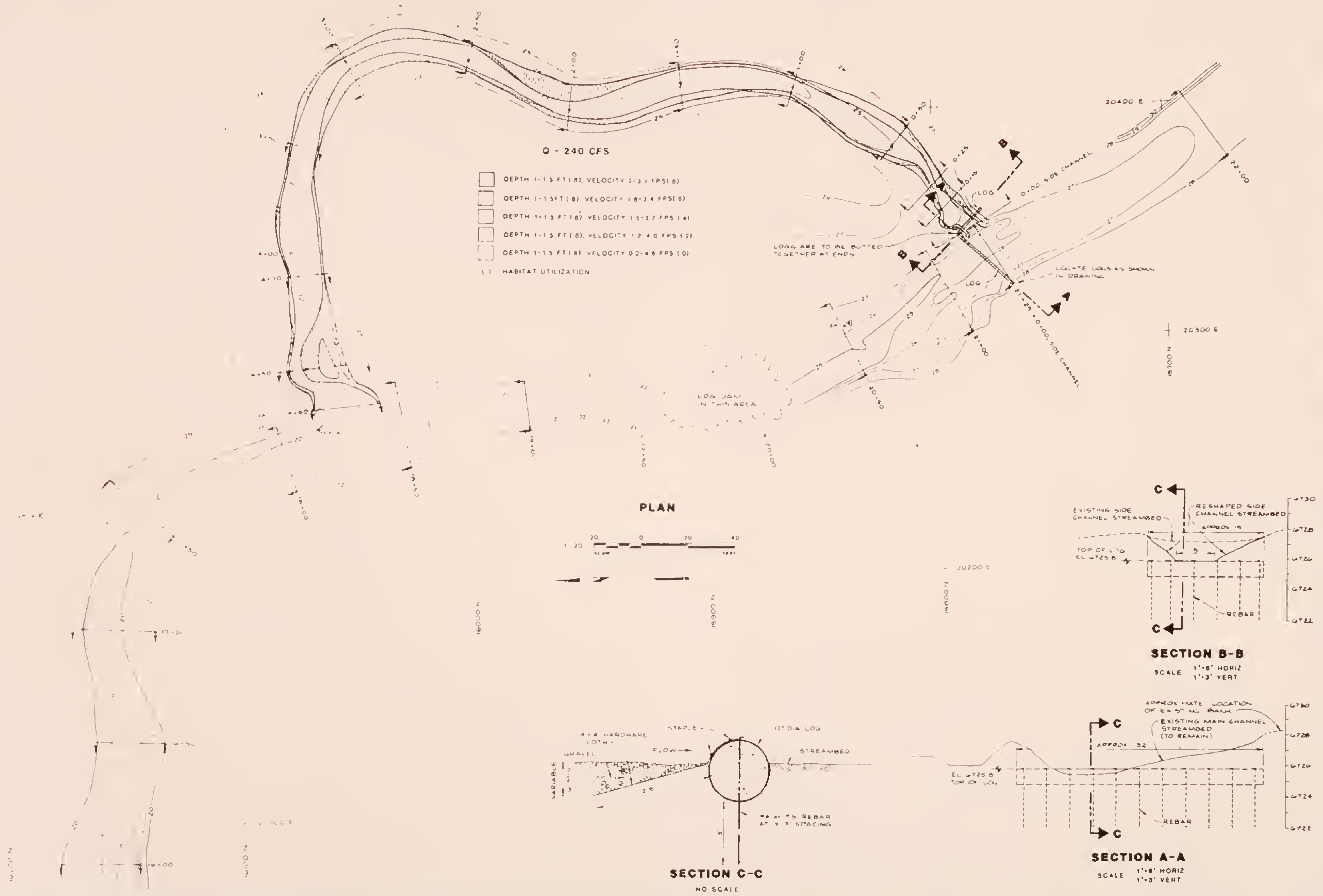
During the 1975 peak of 240 cfs, it is estimated that about 2300 square feet of spawning area is present having velocities with HU of 0.0 or higher. Using velocities with HU of 0.8 or greater, the spawning area is approximately 600 square feet. For a discharge of 240 cfs, erosive velocities are becoming a factor, however, estimated velocities are below 6 fps which is permissible for water carrying colloided silts which may be anticipated during peak runoff periods of the year.

Under 100 year flood conditions erosive velocities are also a consideration, however, velocities are still below 6 fps and are not anticipated to be a significant concern to the side channel.

The hydraulic analysis indicates spawning area will be replaced for a wide range of flows and that erosive velocities should not be a significant problem even under 100 year flood conditions. These findings support the use of the proposed log structure.

CONCLUSION

With the proposed design, it appears desirable depths and velocities can be achieved in a large area of the side channel for a wide range of flow conditions. Under flooding conditions velocities slightly exceed erodible velocities for clear water, however, they are below erodible velocities for waters transporting colloidal silts. Therefore, a simple, inexpensive, visually acceptable design as proposed should perform acceptably under the full range of anticipated flow conditions. Use of a gated structure is not recommended for numerous reasons including the need for an operator, the expense and continual maintenance, problems with debris, ice and fish passage, appearance, and a large upstream pond.


Q - 240 CFS
DEPTH 1-1.5 FT (8), VELOCITY 2-3.1 FPS (8)
DEPTH 1-1.5 FT (8), VELOCITY 1.8-3.4 FPS (8)
DEPTH 1-1.5 FT (8), VELOCITY 1.5-3.7 FPS (4)
DEPTH 1-1.5 FT (8), VELOCITY 1.2-4.0 FPS (2)
DEPTH 1-1.5 FT (8), VELOCITY 0.2-4.8 FPS (0)
( ) HABITAT UTILIZATION
LOGS ARE TO BE BUTTED TOGETHER AT ENDS
LOG
LOCATE LOGS AS SHOWN IN DRAWING
0+00 SIDE CHANNEL
LOG JAM IN THIS AREA
20400 E
20300 E
20200 E
PLAN
SCALE 1"=20' feet
EXISTING SIDE CHANNEL STREAMBED
RESHAPED SIDE CHANNEL STREAMBED
APPROX 15'
TOP OF LOG EL 6725.8
REBAR
SECTION B-B
SCALE 1"=6' HORIZ 1"=3' VERT
4x4 HARDWARE CLOTH
STAPLE
12" DIA LOG
GRAVEL
FLOW
STREAMBED
VARIABLE
#4 or #5 REBAR AT ± 3' SPACING
SECTION C-C
NO SCALE
APPROXIMATE LOCATION OF EXISTING BANK
EXISTING MAIN CHANNEL STREAMBED (TO REMAIN)
APPROX 32'
EL 6725.8 TOP OF LOG
REBAR
SECTION A-A
SCALE 1"=6' HORIZ 1"=3' VERT
6730
6728
6726
6724
6722

Project No 8M087 121 ID No Date DEC. 8, 1987 Designed Drawn DLF Checked Approved

No	Revision	By	Date
1	[illegible]	DLF	[illegible]
2	[illegible]	[illegible]	[illegible]

HYALITE CREEK

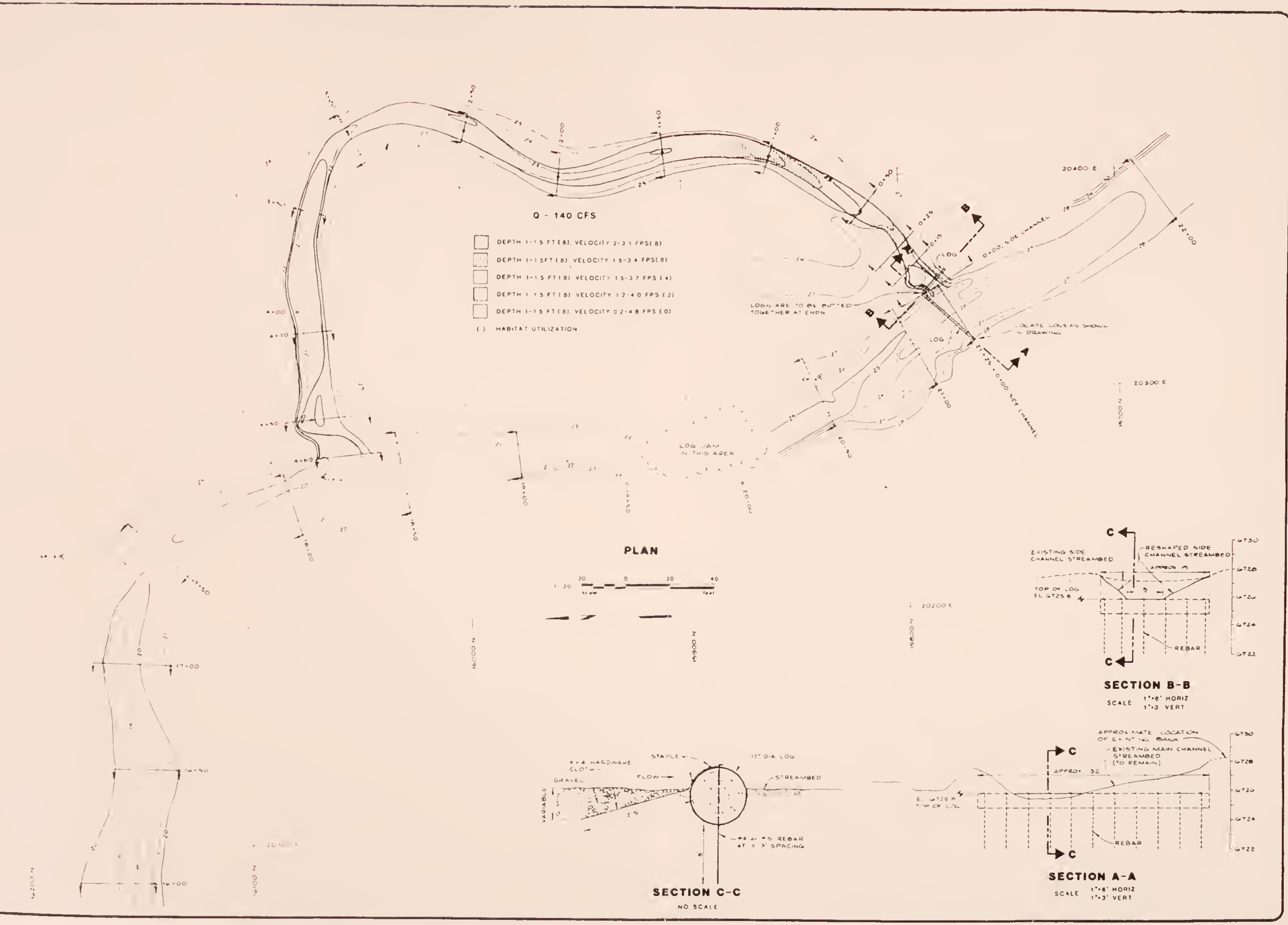
PROPOSED GRAYLING MITIGATION MEASURES

HKM ASSOCIATES
ENGINEERS·PLANNERS

Airport Industrial Park
P.O. Box 31318
Billings, Montana 59107

Branch Offices:
• Libby, Montana
• Sheridan, Wyoming

Sheet No
FIGURE 1.A
of


Q - 140 CFS
☐ DEPTH 1-1.5 FT (8), VELOCITY 2-3.1 FPS (8)
▨ DEPTH 1-1.5 FT (8), VELOCITY 1.8-3.4 FPS (8)
☐ DEPTH 1-1.5 FT (8), VELOCITY 1.5-3.7 FPS (4)
☐ DEPTH 1-1.5 FT (8), VELOCITY 1.2-4.0 FPS (2)
☐ DEPTH 1-1.5 FT (8), VELOCITY 0.2-4.8 FPS (0)
( ) HABITAT UTILIZATION
LOGS ARE TO BE BUTTED TOGETHER AT ENDS
LOG
LOCATE LOGS AS SHOWN IN DRAWING
0+00 SIDE CHANNEL
21+25 = 0+00 SIDE CHANNEL
LOG JAM IN THIS AREA
20400 E
20300 E
20200 E
15700 N
15800 N
15900 N
16000 N
16100 N
22+00
21+00
20+50
20+00
19+50
19+00
18+50
18+00
17+50
17+00
16+50
16+00
PLAN
1" = 20'
20 0 20 40
SCALE FEET
B
A
C
EXISTING SIDE CHANNEL STREAMBED
RESHAPED SIDE CHANNEL STREAMBED
APPROX. 15
TOP OF LOG EL 6725.8
REBAR
6730
6728
6726
6724
6722
SECTION B-B
SCALE 1"=6' HORIZ 1"=3' VERT
APPROXIMATE LOCATION OF EXISTING BANK
EXISTING MAIN CHANNEL STREAMBED (TO REMAIN)
APPROX. 32
EL 6725.8 TOP OF LOG
SECTION A-A
SCALE 1"=6' HORIZ 1"=3' VERT
4×4 HARDWARE CLOTH
GRAVEL
STAPLE
FLOW
12" DIA LOG
STREAMBED
VARIABLE
2.5
#4 or #5 REBAR AT ± 3' SPACING
SECTION C-C
NO SCALE

Project No 8M087 121 ID No Date DEC. 8, 1987 Designed Drawn Checked Approved

No	Revision	By	Date
1	INCORPORATED ... (PMRC) COMMENTS		
2			

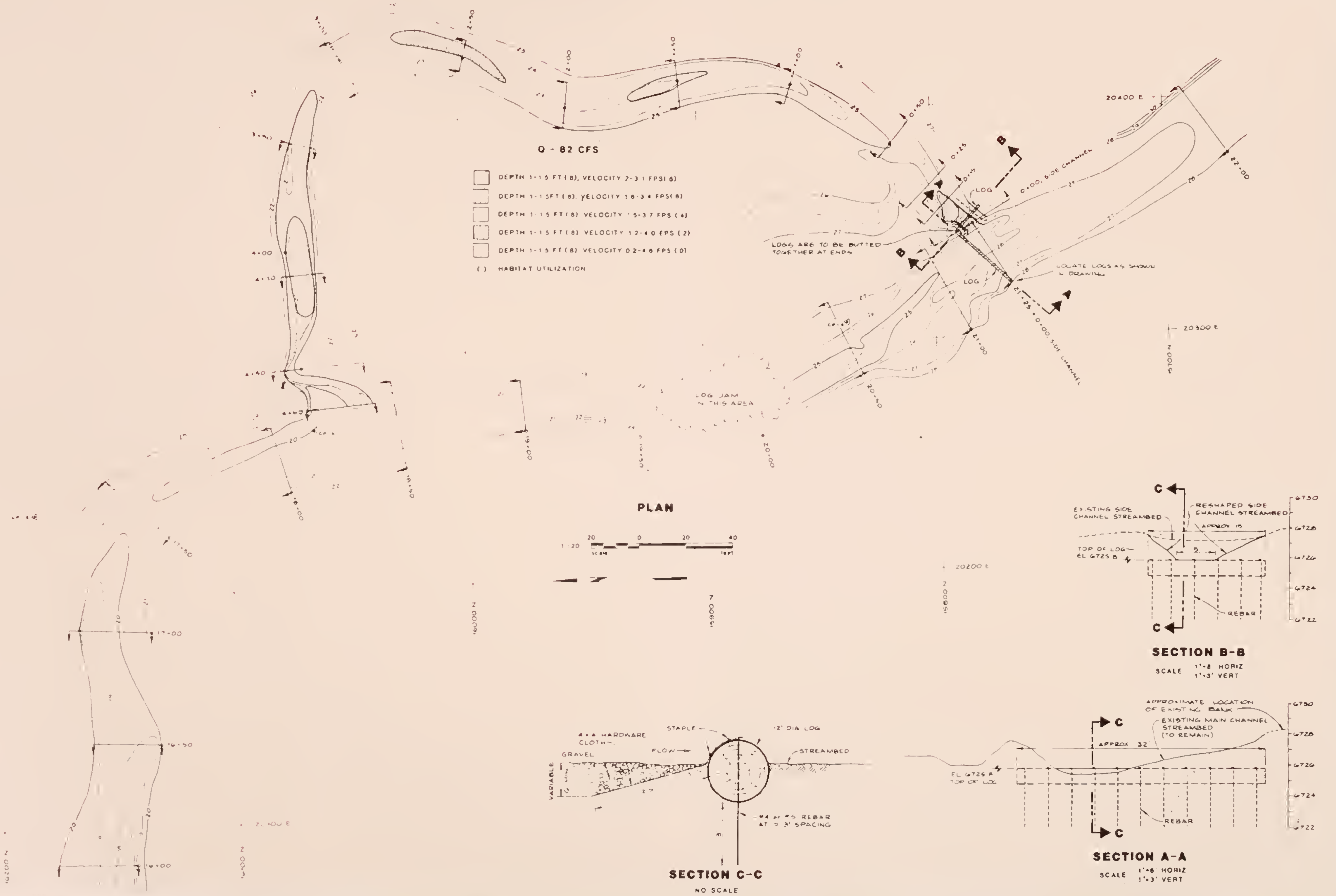
HYALITE CREEK

PROPOSED GRAYLING MITIGATION MEASURES

HKM ASSOCIATES
ENGINEERS·PLANNERS
Airport Industrial Park
P.O. Box 31318
Billings, Montana 59107

Branch Offices:
• Libby, Montana
• Sheridan, Wyoming

Sheet No
FIGURE 1.B
of


Q - 82 CFS
☐ DEPTH 1-1.5 FT (8), VELOCITY 2-3.1 FPS (8)
☐ DEPTH 1-1.5FT (8), VELOCITY 1.8-3.4 FPS (8)
☐ DEPTH 1-1.5 FT (8) VELOCITY 1.5-3.7 FPS (4)
☐ DEPTH 1-1.5 FT (8) VELOCITY 1.2-4.0 FPS (2)
☐ DEPTH 1-1.5 FT (8) VELOCITY 0.2-4.8 FPS (0)
( ) HABITAT UTILIZATION
LOG
LOGS ARE TO BE BUTTED TOGETHER AT ENDS
LOCATE LOGS AS SHOWN IN DRAWING
0+00 SIDE CHANNEL
21+25
B
A
20400 E
20300 E
20200 E
20100 E
15700 N
15800 N
15900 N
16000 N
16100 N
16200 N
22+00
21+00
20+50
20+00
19+00
18+50
18+00
17+50
17+00
16+50
16+00
LOG JAM IN THIS AREA
1"=20
20 0 20 40
EXISTING SIDE CHANNEL STREAMBED
RESHAPED SIDE CHANNEL STREAMBED
APPROX 15
TOP OF LOG EL 6725.8
2
REBAR
6730
6728
6726
6724
6722
C
APPROXIMATE LOCATION OF EXISTING BANK
EXISTING MAIN CHANNEL STREAMBED (TO REMAIN)
APPROX 32'
EL 6725.8 TOP OF LOG
4×4 HARDWARE CLOTH
STAPLE
12" DIA LOG
GRAVEL
FLOW
STREAMBED
VARIABLE
2:1
#4 or #5 REBAR AT ± 3' SPACING

PLAN

SECTION B-B

SCALE 1"=8 HORIZ
1"=3' VERT

SECTION A-A

SCALE 1"=8' HORIZ
1"=3' VERT

SECTION C-C

NO SCALE

Project No 8M087 121 ID No Date DEC. 8, 1987 Designed dss Drawn bjl Checked dss Approved

No	Revision	By	Date
1	INCORPORATED [illegible] COMMENTS	bjl	1-11-88
2	[illegible]	[illegible]	[illegible]

HYALITE CREEK

PROPOSED GRAYLING MITIGATION MEASURES

HKM ASSOCIATES
ENGINEERS·PLANNERS
Airport Industrial Park
P.O. Box 31318
Billings, Montana 59107

Branch Offices:
Libby, Montana
Sheridan, Wyoming

Sheet No
FIGURE 1.C
of

APPENDIX J-2
GRAYLING SPAWNING MITIGATION STRUCTURE TEST RESULTS

January 16, 1990
8M087.140/WPWATRES1315

Mr. Bob Clark
Department of Natural Resources
& Conservation
Lee Metcalf Building
1520 East 6th Avenue
Helena, MT 59620

RE: Middle Creek Dam Grayling Structure

Dear Mr. Clark:

The DNRC authorized HKM to make a field visit to the permanent grayling mitigation structure and to review Mel McBeath's flow measurements in the side channel to determine the amount of habitat being provided.

Field Visit

Gary Elwell of HKM and Bob Clark of DNRC visited the structure on June 22, 1989. Mel McBeath was taking flow measurements at the same time. The structure appeared to be functioning properly, however, some erosion occurred in the corner of the structure where the two sills come together. This corner was reinforced with hand placed rock, however, it was not sufficient to prevent erosion.

Habitat

The DNRC has provided HKM with 3 sets of flow measurements and channel cross sections taken during the spring of 1989. Measurements were taken on May 16, June 15, and June 22. Attached are spreadsheets for each of these measurements which estimate the amount of habitat in the side channel.

The spreadsheets are arranged by side channel station number (i.e. 0+50, 1+00, etc.). Station 0+00 is located at the diversion, with station numbers increasing in the downstream direction. RL stands for reach length, which equals the sum of half the distance to the next upstream and downstream sections. Columns in the spreadsheet are as follows:

Column W - Incremental channel width in feet
Column D - Water depth in feet in each increment of the channel
Column SI - Suitability Index for depth from Fernet's 1987 report, see attached SI curve

Column V - Average velocity in fps in each increment of the channel
Column SI - Suitability Index for velocity from Fernet's 1987 report, see attached SI curve
Column SI*SI - Product of the two SI values
Column TA - Total area in sq ft or RL*W in each increment of the channel
Column WT A - Weighted area in sq ft or SI*SI*RL*W in each increment of the channel
Column Q - Flow in cfs in each increment of the channel or W*D*V

The results of this analysis are as follows:

	Area in sq ft					Side Channel	Total
Date	2/ Excellent	3/ Good	4/ Marginal	Total	Total Good and Excellent	Q in cfs	Q in cfs
1986 (Reach 1)[5/]	348	736	2748	3832	1084		
1987 (V Structure)[6/]	270	885			1155		
5/16/89	238	1122	1809	3169	1360	13.1	NA
6/15/89	454	1198	1854	3506	1652	23.0	120[1/]
6/22/89	92	653	1940	2685	745	11.0	75

1/ Need to verify with McBeath.
2/ Greater than or equal to SI*SI = .64 (.8*.8) and SI*SI = .63 (.9*.7)
3/ Greater than or equal to SI*SI = .25 (.5*.5) and SI*SI = .24 (.6*.4)
4/ Greater than SI*SI = 0.
5/ Included to show that habitat in side channel exceeds habitat available in Reach 1 during 1986.
6/ Structure constructed in 1987 to test habitat enhancement methods.

A flow of 120 cfs is approximately equal to the estimated bank full discharge of 140 cfs. The HEC2 model said approximately 35 percent of a total flow of 140 cfs would go down the side channel. Flow measurements indicate about 23 cfs or about 20 percent of the 120 cfs is going down the side channel. Erosion at the corner where the sills join is allowing more water to flow down the main channel than would otherwise be possible. Once the corner is reinforced, the distribution of flows should be closer to this design values. With 23 cfs in the side channel, there is more excellent and good habitat in the side channel than will be lost as a result of raising the reservoir.

With 75 cfs total flow, about 11.0 cfs flowed through the side channel. A flow of 75 cfs reflects about the low flow estimate of 82 cfs used during design. As described previously, the relative amount of water entering the side channel should increase after the eroded section is fixed. With a flow of 11.0 cfs in the side channel, the amount of excellent and good habitat is about 745 square feet, which is less than that in 1986. However, the results for May 16 indicate a minor increase in flow from 11.0 cfs up to 13.1 cfs would raise the amount of excellent and good habitat up to 1360 square feet which exceeds the 1986 amounts. This increase in side channel flow should take place after the erosion is repaired.

It appears that for a range of flows from low flow to bank full the amount of good and excellent habitat exceeds that from 1986 (Reach 1) and 1987 (V structure). HEC2 runs for a side channel flow of 22 cfs were compared with field measurements for 23 cfs and there is good concurrence. The model indicates the amount of habitat will increase as side channel flows increase, which should happen now that the erosion at the corner of the sills has been eliminated.

Conclusions

The hydraulics of the structure and side channel are satisfactory. Erosion that has occurred at the corner of the two sills has been repaired using log structures similar to those already in place. The logs were constructed adjacent to the downstream main channel bank and the left side channel bank, starting from the existing corner. Additional flow measurements can be taken next spring.

If you have any questions, feel free to call.

Sincerely,

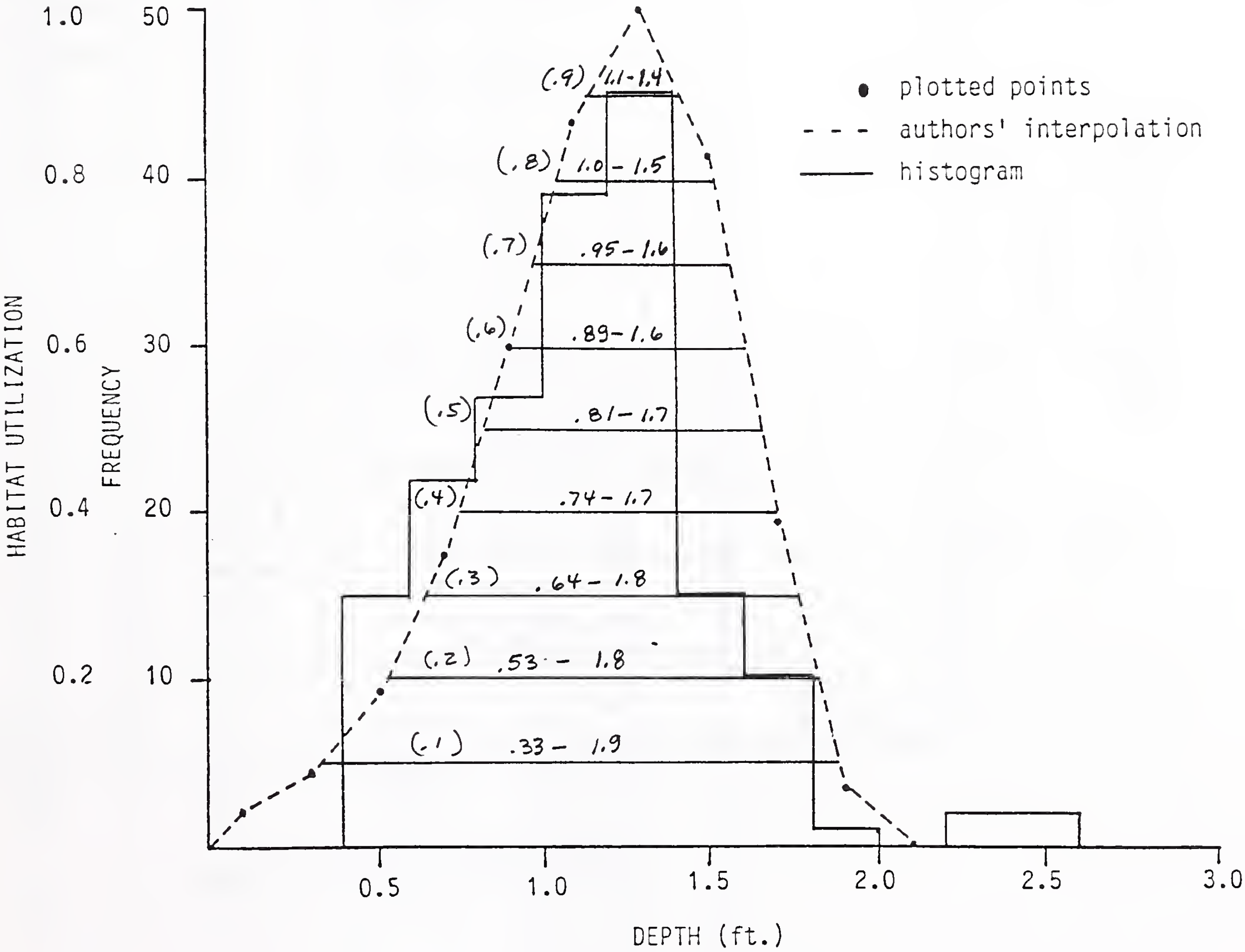
HKM ASSOCIATES

Gary Elwell, P.E.

GE/cmc

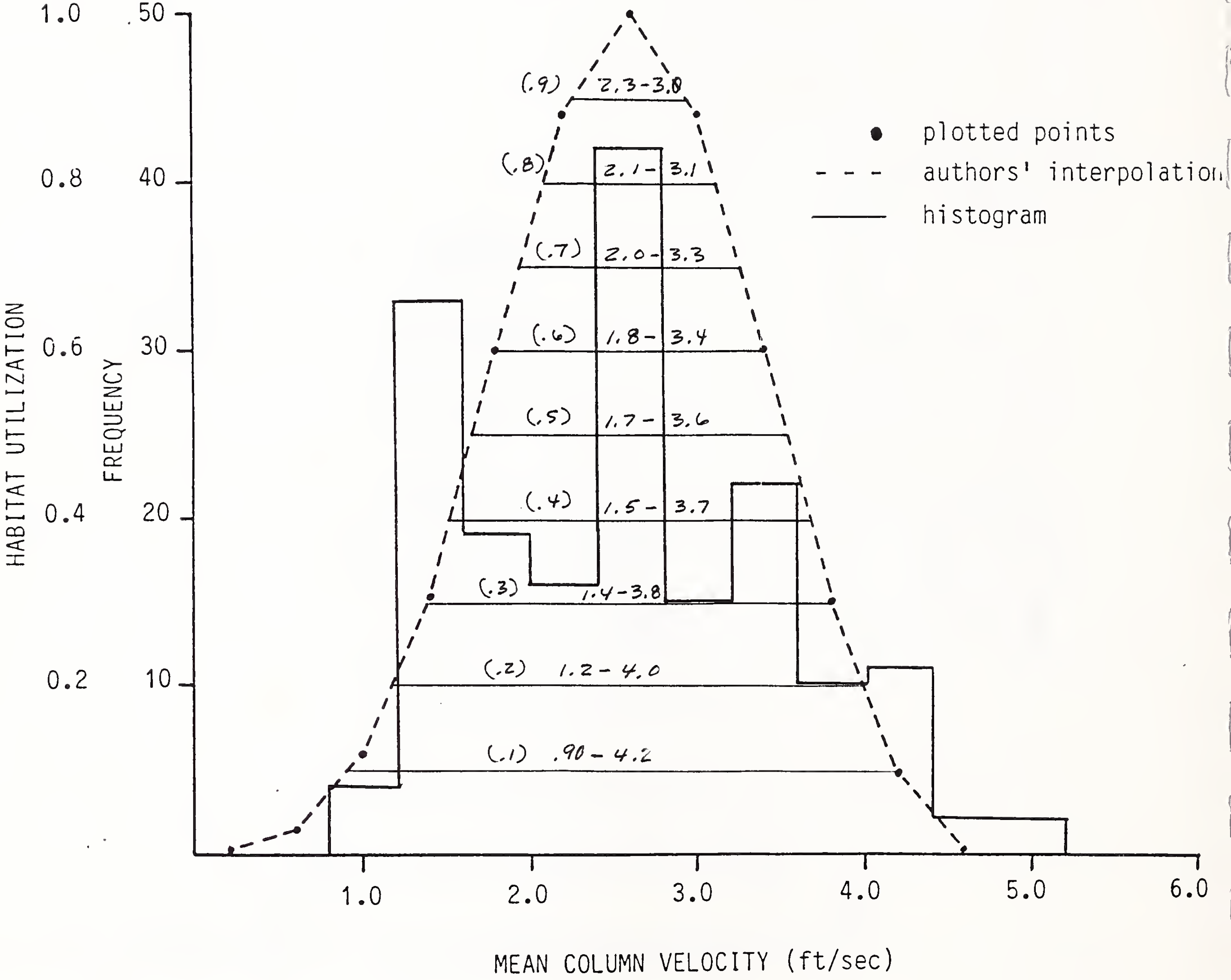
Attachments

Figure 9. Habitat utilization curve and histogram, depth in feet 1986 and 1987 data.



13-JUL-89

Figure 10. Habitat utilization curve and histogram, mean column velocity in cm/sec, 1986 and 1987 data.



13-JUL-89

5-16-89

0+00 RL= 25

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1.5	0.00	0	0.00	0	0	37.5	0.0	0.0
1.75	0.60	0.2	0.80	0	0	43.8	0.0	0.8
0.5	0.80	0.4	1.06	0.1	0.04	12.5	0.5	0.4
0.5	0.80	0.4	1.33	0.2	0.08	12.5	1.0	0.5
0.5	1.00	0.8	1.65	0.4	0.32	12.5	4.0	0.8
0.5	1.00	0.8	1.84	0.6	0.48	12.5	6.0	0.9
0.5	1.10	0.9	2.20	0.8	0.72	12.5	9.0	1.2
0.5	1.10	0.9	2.34	0.9	0.81	12.5	10.1	1.3
0.5	1.05	0.8	2.34	0.9	0.72	12.5	9.0	1.2
0.5	0.80	0.4	2.44	0.9	0.36	12.5	4.5	1.0
0.5	0.75	0.4	2.74	0.9	0.36	12.5	4.5	1.0
0.5	0.65	0.3	2.68	0.9	0.27	12.5	3.4	0.9
0.5	0.50	0.1	2.86	0.9	0.09	12.5	1.1	0.7
0.5	0.40	0.1	2.68	0.9	0.09	12.5	1.1	0.5
0.5	0.20	0	2.10	0.8	0	12.5	0.0	0.2
0.5	0.40	0.1	2.24	0.8	0.08	12.5	1.0	0.4
0.25	0.50	0.1	1.57	0.4	0.04	6.3	0.3	0.2
						262.5	55.5	12.2

0+50 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.5	0.00	0	0.00	0	0	25.0	0.0	0.0
1	1.00	0.8	0.00	0	0	50.0	0.0	0.0
1	0.70	0.3	0.00	0	0	50.0	0.0	0.0
1	0.70	0.3	0.00	0	0	50.0	0.0	0.0
0.75	0.70	0.3	0.75	0	0	37.5	0.0	0.4
0.5	1.00	0.8	0.91	0.1	0.08	25.0	2.0	0.5
1	1.40	0.9	0.50	0	0	50.0	0.0	0.7
1	1.40	0.9	0.47	0	0	50.0	0.0	0.7
0.5	1.40	0.9	0.86	0	0	25.0	0.0	0.6
0.5	1.20	0.9	2.74	0.9	0.81	25.0	20.3	1.6
0.5	1.20	0.9	2.61	0.9	0.81	25.0	20.3	1.6
0.5	1.10	0.9	2.44	0.9	0.81	25.0	20.3	1.3
0.5	1.00	0.8	2.20	0.8	0.64	25.0	16.0	1.1
0.5	1.00	0.8	2.74	0.9	0.72	25.0	18.0	1.4
0.5	0.95	0.7	3.13	0.7	0.49	25.0	12.2	1.5
0.5	0.90	0.6	2.00	0.7	0.42	25.0	10.5	0.9
0.5	0.90	0.6	2.03	0.7	0.42	25.0	10.5	0.9
0.5	0.95	0.7	1.33	0.2	0.14	25.0	3.5	0.6
3.5	0.4	0.1	1.25	0.2	0.02	175.0	3.5	1.8
3.25	0	0	0	0	0	162.5	0.0	0.0
						925.0	137.0	15.5

1+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.00	0	0.00	0	0	12.5	0.0	0.0
0.5	0.55	0.2	0.91	0.1	0.02	25.0	0.5	0.3
0.5	0.55	0.2	1.80	0.6	0.12	25.0	3.0	0.5
0.5	0.80	0.4	2.44	0.9	0.36	25.0	9.0	1.0
0.5	0.80	0.4	3.50	0.5	0.2	25.0	5.0	1.4
0.5	0.60	0.2	2.86	0.9	0.18	25.0	4.5	0.9
0.5	0.50	0.1	3.57	0.5	0.05	25.0	1.3	0.9
0.5	0.85	0.5	3.43	0.5	0.25	25.0	6.3	1.5
0.5	0.70	0.3	3.28	0.7	0.21	25.0	5.2	1.1
0.5	0.65	0.3	2.86	0.9	0.27	25.0	6.8	0.9
0.5	0.65	0.3	2.50	0.9	0.27	25.0	6.8	0.8
0.5	0.70	0.3	2.00	0.7	0.21	25.0	5.2	0.7
0.5	0.65	0.3	2.10	0.8	0.24	25.0	6.0	0.7
0.5	0.60	0.2	1.88	0.6	0.12	25.0	3.0	0.6
0.5	0.55	0.2	1.73	0.5	0.1	25.0	2.5	0.5
0.5	0.55	0.2	1.88	0.6	0.12	25.0	3.0	0.5
0.75	0.60	0.2	1.38	0.2	0.04	37.5	1.5	0.6
0.5	0	0	0	0	0	25.0	0.0	0.0
						450.0	69.5	12.8

1+50 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.40	0.1	0.35	0	0	12.5	0.0	0.0
0.5	0.50	0.1	0.70	0	0	25.0	0.0	0.2
0.5	0.55	0.2	1.05	0.1	0.02	25.0	0.5	0.3
0.5	0.60	0.2	2.44	0.9	0.18	25.0	4.5	0.7
0.5	0.70	0.3	2.86	0.9	0.27	25.0	6.8	1.0
0.5	0.80	0.4	3.28	0.7	0.28	25.0	7.0	1.3
0.5	0.80	0.4	3.21	0.7	0.28	25.0	7.0	1.3
0.5	0.70	0.3	2.69	0.9	0.27	25.0	6.8	0.9
0.5	0.80	0.4	2.55	0.9	0.36	25.0	9.0	1.0
0.5	0.80	0.4	3.21	0.7	0.28	25.0	7.0	1.3
0.5	0.65	0.3	3.70	0.4	0.12	25.0	3.0	1.2
0.5	0.80	0.4	2.30	0.9	0.36	25.0	9.0	0.9
0.5	0.80	0.4	2.50	0.9	0.36	25.0	9.0	1.0
0.5	0.75	0.4	2.15	0.8	0.32	25.0	8.0	0.8
0.5	0.65	0.3	1.25	0.2	0.06	25.0	1.5	0.4
0.5	0.40	0.1	1.03	0.1	0.01	25.0	0.3	0.2
1	0.40	0.1	0.79	0	0	50.0	0.0	0.3
0.75	0	0	0	0	0	37.5	0.0	0.0
						475.0	79.3	12.9

```
2+00        RL=         50
    W         D        SI          V        SI      SI*SI      T A      WT A       Q
   0.25      0.00        0       0.00        0          0      12.5      0.0      0.0
    0.5      0.25        0       1.61      0.4          0      25.0      0.0      0.2
   1.75      0.20        0       1.04      0.1          0      87.5      0.0      0.4
      2      0.15        0       1.68      0.4          0     100.0      0.0      0.5
   0.75      0.20        0       0.90      0.1          0      37.5      0.0      0.1
    0.5      0.20        0       3.12      0.7          0      25.0      0.0      0.3
    0.5      0.30        0       3.25      0.7          0      25.0      0.0      0.5
    0.5      0.35      0.1       3.57      0.5       0.05      25.0      1.3      0.6
    0.5      0.40      0.1       3.48      0.5       0.05      25.0      1.3      0.7
    0.5      0.60      0.2       3.12      0.7       0.14      25.0      3.5      0.9
    0.5      0.80      0.4       3.05      0.8       0.32      25.0      8.0      1.2
    0.5      0.75      0.4       2.99      0.9       0.36      25.0      9.0      1.1
    0.5      0.70      0.3       2.39      0.9       0.27      25.0      6.8      0.8
    0.5      0.70      0.3       3.05      0.8       0.24      25.0      6.0      1.1
    0.5      0.60      0.2       3.33      0.6       0.12      25.0      3.0      1.0
    0.5      0.65      0.3       3.05      0.8       0.24      25.0      6.0      1.0
    0.5      0.55      0.2       2.88      0.9       0.18      25.0      4.5      0.8
    0.5       0.4      0.1       2.99      0.9       0.09      25.0      2.3      0.6
    0.5      0.30        0       0.84        0          0      25.0      0.0      0.1
   0.25         0        0          0        0          0      12.5      0.0      0.0

                                                              625.0     51.5     12.0

2+50        RL=         50
    W         D        SI          V        SI      SI*SI      T A      WT A       Q
   0.25      1.00      0.8       0.96      0.1       0.08      12.5      1.0      0.2
    0.5      1.40      0.9       1.92      0.6       0.54      25.0     13.5      1.3
    0.5      1.25      0.9       2.20      0.8       0.72      25.0     18.0      1.4
    0.5      1.25      0.9       1.51      0.4       0.36      25.0      9.0      0.9
    0.5      1.10      0.9       2.05      0.7       0.63      25.0     15.8      1.1
    0.5      0.80      0.4       2.20      0.8       0.32      25.0      8.0      0.9
    0.5      0.75      0.4       2.15      0.8       0.32      25.0      8.0      0.8
    0.5      0.60      0.2       2.15      0.8       0.16      25.0      4.0      0.6
    0.5      0.50      0.1       2.99      0.9       0.09      25.0      2.3      0.7
    0.5      0.45      0.1       2.61      0.9       0.09      25.0      2.3      0.6
    0.5      0.35      0.1       2.86      0.9       0.09      25.0      2.3      0.5
    0.5      0.40      0.1       2.68      0.9       0.09      25.0      2.3      0.5
    0.5       0.3        0       2.55      0.9          0      25.0      0.0      0.4
   0.75      0.30        0       1.80      0.6          0      37.5      0.0      0.4
    0.5         0        0          0        0          0      25.0      0.0      0.0

                                                              375.0     86.3     10.5
```

3+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.5	0.00	0	0.00	0	0	25.0	0.0	0.0
0.75	0.40	0.1	1.58	0.4	0.04	37.5	1.5	0.5
0.5	0.40	0.1	2.00	0.7	0.07	25.0	1.8	0.4
0.5	0.60	0.2	2.92	0.9	0.18	25.0	4.5	0.9
0.5	0.85	0.5	2.61	0.9	0.45	25.0	11.3	1.1
0.5	0.90	0.6	2.74	0.9	0.54	25.0	13.5	1.2
0.5	0.80	0.4	2.80	0.9	0.36	25.0	9.0	1.1
0.5	0.90	0.6	2.74	0.9	0.54	25.0	13.5	1.2
0.5	0.95	0.7	2.86	0.9	0.63	25.0	15.8	1.4
0.5	0.85	0.5	2.86	0.9	0.45	25.0	11.3	1.2
0.5	0.8	0.4	2.74	0.9	0.36	25.0	9.0	1.1
1.25	0.70	0.3	2.68	0.9	0.27	62.5	16.9	2.3
1	0	0	0	0	0	50.0	0.0	0.0
						400.0	107.9	12.5

3+50 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.5	0.00	0	0.00	0	0	25.0	0.0	0.0
0.75	1.20	0.9	0.18	0	0	37.5	0.0	0.2
0.5	1.20	0.9	0.24	0	0	25.0	0.0	0.1
0.5	1.25	0.9	0.25	0	0	25.0	0.0	0.2
0.5	1.10	0.9	0.29	0	0	25.0	0.0	0.2
0.5	1.05	0.8	0.41	0	0	25.0	0.0	0.2
0.5	0.90	0.6	0.80	0	0	25.0	0.0	0.4
0.5	0.80	0.4	1.35	0.2	0.08	25.0	2.0	0.5
0.5	0.75	0.4	1.47	0.3	0.12	25.0	3.0	0.6
0.5	0.80	0.4	1.54	0.4	0.16	25.0	4.0	0.6
0.5	1	0.8	0.8	0	0	25.0	0.0	0.4
0.5	1.20	0.9	0.42	0	0	25.0	0.0	0.3
0.5	1.35	0.9	0.75	0	0	25.0	0.0	0.5
0.5	1.5	0.8	1.06	0.1	0.08	25.0	2.0	0.8
0.5	1.7	0.5	1.54	0.4	0.2	25.0	5.0	1.3
0.5	1.7	0.5	2.29	0.8	0.4	25.0	10.0	1.9
0.5	1.7	0.5	1.11	0.1	0.05	25.0	1.3	0.9
0.5	1.4	0.9	1.15	0.1	0.09	25.0	2.3	0.8
0.75	1.3	0.9	1.01	0.1	0.09	37.5	3.4	1.0
0.5	0	0	0	0	0	25.0	0.0	0.0
						525.0	32.9	10.8

4+00 RL= 45

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.70	0.3	0.00	0	0	11.3	0.0	0.0
0.75	0.80	0.4	0.00	0	0	33.8	0.0	0.0
1	0.80	0.4	0.00	0	0	45.0	0.0	0.0
1	0.90	0.6	0.35	0	0	45.0	0.0	0.3
0.75	1.15	0.9	0.49	0	0	33.8	0.0	0.4
0.5	1.40	0.9	0.66	0	0	22.5	0.0	0.5
0.5	1.30	0.9	0.80	0	0	22.5	0.0	0.5
0.5	1.40	0.9	0.83	0	0	22.5	0.0	0.6
0.5	1.60	0.7	0.95	0.1	0.07	22.5	1.6	0.8
0.5	1.80	0.3	1.08	0.1	0.03	22.5	0.7	1.0
0.5	2	0	1.62	0.4	0	22.5	0.0	1.6
0.5	2.00	0	2.00	0.7	0	22.5	0.0	2.0
0.5	2	0	2.15	0.8	0	22.5	0.0	2.2
0.5	1.9	0.1	2.1	0.8	0.08	22.5	1.8	2.0
0.5	1.9	0.1	1.92	0.6	0.06	22.5	1.4	1.8
0.5	1.8	0.3	1.65	0.4	0.12	22.5	2.7	1.5
0.5	1.9	0.1	1.08	0.1	0.01	22.5	0.2	1.0
0.5	1.6	0.7	0.84	0	0	22.5	0.0	0.7
0.5	1.4	0.9	0.57	0	0	22.5	0.0	0.4
0.75	1.05	0.8	0.35	0	0	33.8	0.0	0.3
1.25	1	0.8	0.35	0	0	56.3	0.0	0.4
0.75	0	0	0	0	0	33.8	0.0	0.0
						607.5	8.3	17.9

4+40 RL= 49

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.5	0.00	0	0.00	0	0	24.5	0.0	0.0
0.75	0.75	0.4	0.00	0	0	36.8	0.0	0.0
0.5	0.85	0.5	0.46	0	0	24.5	0.0	0.2
0.5	1.00	0.8	0.65	0	0	24.5	0.0	0.3
0.5	1.00	0.8	1.25	0.2	0.16	24.5	3.9	0.6
0.5	1.00	0.8	1.35	0.2	0.16	24.5	3.9	0.7
0.5	1.00	0.8	1.19	0.1	0.08	24.5	2.0	0.6
0.5	1.00	0.8	1.41	0.3	0.24	24.5	5.9	0.7
0.5	0.90	0.6	1.65	0.4	0.24	24.5	5.9	0.7
0.5	0.90	0.6	1.96	0.6	0.36	24.5	8.8	0.9
0.5	0.95	0.7	2	0.7	0.49	24.5	12.0	1.0
0.5	0.90	0.6	2.05	0.7	0.42	24.5	10.3	0.9
0.5	0.85	0.5	2.1	0.8	0.4	24.5	9.8	0.9
0.5	0.8	0.4	1.8	0.6	0.24	24.5	5.9	0.7
0.5	0.8	0.4	1.51	0.4	0.16	24.5	3.9	0.6
0.5	0.7	0.3	1.44	0.3	0.09	24.5	2.2	0.5
0.5	0.6	0.2	1.38	0.2	0.04	24.5	1.0	0.4
0.5	0.55	0.2	1.33	0.2	0.04	24.5	1.0	0.4
0.5	0.5	0.1	1.41	0.3	0.03	24.5	0.7	0.4
0.5	0.5	0.1	1.41	0.3	0.03	24.5	0.7	0.4
0.5	0.4	0.1	1.19	0.1	0.01	24.5	0.2	0.2
0.5	0.5	0.1	1.28	0.2	0.02	24.5	0.5	0.3
0.5	0.5	0.1	1.15	0.1	0.01	24.5	0.2	0.3
0.5	0.45	0.1	1.03	0.1	0.01	24.5	0.2	0.2
0.5	0.4	0.1	1.11	0.1	0.01	24.5	0.2	0.2
0.75	0.4	0.1	1.11	0.1	0.01	36.8	0.4	0.3
1	0.3	0	0.72	0	0	49.0	0.0	0.2
1	0.4	0.1	0.57	0	0	49.0	0.0	0.2
2	0.4	0.1	0.55	0	0	98.0	0.0	0.4
1.5	0	0	0	0	0	73.5	0.0	0.0
						931.0	79.7	13.3
						5576.0	707.8	130.6
							0.13	13.1

13-Jul-89

6-15-89

0+07 RL= 29

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1	0.00	0	0.00	0	0	29.0	0.0	0.0
1.25	0.30	0	0.76	0	0	36.3	0.0	0.3
0.5	0.20	0	0.69	0	0	14.5	0.0	0.1
0.5	0.35	0.1	0.83	0	0	14.5	0.0	0.1
0.75	0.35	0.1	0.77	0	0	21.8	0.0	0.2
0.5	0.20	0	0.39	0	0	14.5	0.0	0.0
0.5	0.60	0.2	0.84	0	0	14.5	0.0	0.3
0.75	1.15	0.9	1.55	0.4	0.36	21.8	7.8	1.3
0.5	1.10	0.9	1.92	0.6	0.54	14.5	7.8	1.1
0.5	1.10	0.9	2.10	0.8	0.72	14.5	10.4	1.2
0.5	1.10	0.9	2.50	0.9	0.81	14.5	11.7	1.4
0.5	1.15	0.9	2.44	0.9	0.81	14.5	11.7	1.4
0.5	1.2	0.9	2.5	0.9	0.81	14.5	11.7	1.5
0.5	1.2	0.9	2.8	0.9	0.81	14.5	11.7	1.7
0.5	1.3	0.9	2.69	0.9	0.81	14.5	11.7	1.7
0.5	1.2	0.9	2.8	0.9	0.81	14.5	11.7	1.7
0.5	1.3	0.9	3.28	0.7	0.63	14.5	9.1	2.1
0.5	1.1	0.9	3.06	0.8	0.72	14.5	10.4	1.7
0.5	1.05	0.8	2.74	0.9	0.72	14.5	10.4	1.4
0.5	0.85	0.5	2.5	0.9	0.45	14.5	6.5	1.1
0.5	0.90	0.6	1.35	0.2	0.12	14.5	1.7	0.6
0.25	0.00	0	0.00	0	0	7.3	0.0	0.0
						362.5	134.9	20.9

GRAY615

0+50 RL= 46

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1	0.00	0	0.00	0	0	46.0	0.0	0.0
1.5	1.20	0.9	0.29	0	0	69.0	0.0	0.5
0.75	1.20	0.9	0.23	0	0	34.5	0.0	0.2
0.5	1.30	0.9	0.53	0	0	23.0	0.0	0.3
0.5	1.20	0.9	0.72	0	0	23.0	0.0	0.4
0.5	1.20	0.9	0.78	0	0	23.0	0.0	0.5
0.5	1.60	0.7	0.84	0	0	23.0	0.0	0.7
0.5	1.65	0.5	1.76	0.5	0.25	23.0	5.8	1.5
0.5	1.70	0.5	1.47	0.3	0.15	23.0	3.4	1.2
0.5	1.70	0.5	1.76	0.5	0.25	23.0	5.8	1.5
0.5	1.70	0.5	1.11	0.1	0.05	23.0	1.2	0.9
0.5	1.6	0.7	1.54	0.4	0.28	23.0	6.4	1.2
0.5	1.6	0.7	1.65	0.4	0.28	23.0	6.4	1.3
0.5	1.6	0.7	1.88	0.6	0.42	23.0	9.7	1.5
0.5	1.5	0.8	2.44	0.9	0.72	23.0	16.6	1.8
0.5	1.5	0.8	2.5	0.9	0.72	23.0	16.6	1.9
0.5	1.4	0.9	1.76	0.5	0.45	23.0	10.4	1.2
0.5	1.25	0.9	0.99	0.1	0.09	23.0	2.1	0.6
0.5	1.1	0.9	1.08	0.1	0.09	23.0	2.1	0.6
0.5	0.9	0.6	1.67	0.4	0.24	23.0	5.5	0.8
0.5	0.55	0.2	1.41	0.3	0.06	23.0	1.4	0.4
0.5	0.6	0.2	1.25	0.2	0.04	23.0	0.9	0.4
0.75	0.5	0.1	0.83	0	0	34.5	0.0	0.3
1	0.5	0.1	0.97	0.1	0.01	46.0	0.5	0.5
1	0.50	0.1	1.28	0.2	0.02	46.0	0.9	0.6
3	0.3	0	1.01	0.1	0	138.0	0.0	0.9
2.5	0	0	0	0	0	115.0	0.0	0.0
						966.0	95.5	21.9

1+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.30	0	0.20	0	0	12.5	0.0	0.0
0.5	0.95	0.7	0.40	0	0	25.0	0.0	0.2
0.5	1.00	0.8	1.51	0.4	0.32	25.0	8.0	0.8
0.5	1.05	0.8	2.61	0.9	0.72	25.0	18.0	1.4
0.5	1.05	0.8	3.13	0.7	0.56	25.0	14.0	1.6
0.5	1.10	0.9	3.89	0.2	0.18	25.0	4.5	2.1
0.5	1.20	0.9	4.75	0	0	25.0	0.0	2.9
0.5	1.15	0.9	4.16	0.1	0.09	25.0	2.3	2.4
0.5	1.20	0.9	2.74	0.9	0.81	25.0	20.3	1.6
0.5	1.20	0.9	3.37	0.6	0.54	25.0	13.5	2.0
0.5	1.10	0.9	3.37	0.6	0.54	25.0	13.5	1.9
0.5	0.80	0.4	3.21	0.7	0.28	25.0	7.0	1.3
0.5	0.65	0.3	3.57	0.5	0.15	25.0	3.8	1.2
0.5	0.65	0.3	3.13	0.7	0.21	25.0	5.2	1.0
0.5	0.60	0.2	3.28	0.7	0.14	25.0	3.5	1.0
0.5	0.6	0.2	4.16	0.1	0.02	25.0	0.5	1.2
0.75	0.50	0.1	3.37	0.6	0.06	37.5	2.3	1.3
0.5	0	0	0	0	0	25.0	0.0	0.0
						450.0	116.3	23.8

13-Jul-89

1+50 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.65	0.3	0.50	0	0	12.5	0.0	0.1
0.5	0.70	0.3	0.99	0.1	0.03	25.0	0.8	0.3
0.5	0.80	0.4	1.30	0.2	0.08	25.0	2.0	0.5
0.5	0.95	0.7	2.20	0.8	0.56	25.0	14.0	1.0
0.5	1.00	0.8	3.28	0.7	0.56	25.0	14.0	1.6
0.5	1.10	0.9	3.72	0.3	0.27	25.0	6.8	2.0
0.5	1.10	0.9	3.65	0.4	0.36	25.0	9.0	2.0
0.5	1.00	0.8	3.13	0.7	0.56	25.0	14.0	1.6
0.5	1.00	0.8	3.21	0.7	0.56	25.0	14.0	1.6
0.5	0.90	0.6	2.61	0.9	0.54	25.0	13.5	1.2
0.5	0.90	0.6	3.31	0.6	0.36	25.0	9.0	1.5
0.5	0.85	0.5	3.98	0.2	0.1	25.0	2.5	1.7
0.5	0.80	0.4	3.37	0.6	0.24	25.0	6.0	1.3
0.5	0.70	0.3	2.61	0.9	0.27	25.0	6.8	0.9
0.5	0.6	0.2	2.2	0.8	0.16	25.0	4.0	0.7
0.5	0.5	0.1	1.33	0.2	0.02	25.0	0.5	0.3
1	0.55	0.2	1.23	0.2	0.04	50.0	2.0	0.7
0.75	0	0	0	0	0	37.5	0.0	0.0
						475.0	118.8	19.1

2+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.40	0.1	0.67	0	0	12.5	0.0	0.1
0.5	0.45	0.1	1.33	0.2	0.02	25.0	0.5	0.3
1.25	0.40	0.1	0.86	0	0	62.5	0.0	0.4
1.5	0.40	0.1	1.67	0.4	0.04	75.0	3.0	1.0
1	0.35	0.1	2.80	0.9	0.09	50.0	4.5	1.0
0.75	0.40	0.1	3.43	0.5	0.05	37.5	1.9	1.0
0.5	0.40	0.1	2.10	0.8	0.08	25.0	2.0	0.4
0.5	0.50	0.1	3.21	0.7	0.07	25.0	1.8	0.8
0.5	0.60	0.2	2.92	0.9	0.18	25.0	4.5	0.9
0.5	0.70	0.3	2.86	0.9	0.27	25.0	6.8	1.0
0.5	0.90	0.6	3.89	0.2	0.12	25.0	3.0	1.8
0.5	0.9	0.6	3.89	0.2	0.12	25.0	3.0	1.8
0.5	0.9	0.6	3.8	0.3	0.18	25.0	4.5	1.7
0.5	0.95	0.7	3.89	0.2	0.14	25.0	3.5	1.8
0.5	0.9	0.6	3.5	0.5	0.3	25.0	7.5	1.6
0.5	0.9	0.6	3.5	0.5	0.3	25.0	7.5	1.6
0.5	1	0.8	4.26	0	0	25.0	0.0	2.1
0.5	0.75	0.4	3.8	0.3	0.12	25.0	3.0	1.4
0.5	0.8	0.4	2.92	0.9	0.36	25.0	9.0	1.2
0.5	0.6	0.2	1.41	0.3	0.06	25.0	1.5	0.4
0.75	0.45	0.1	1.15	0.1	0.01	37.5	0.4	0.4
0.5	0	0	0	0	0	25.0	0.0	0.0
						675.0	67.8	22.6

2+50 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	1.50	0.8	0.87	0	0	12.5	0.0	0.3
0.5	1.40	0.9	1.73	0.5	0.45	25.0	11.3	1.2
0.5	1.40	0.9	2.50	0.9	0.81	25.0	20.3	1.8
0.5	1.20	0.9	2.61	0.9	0.81	25.0	20.3	1.6
0.5	1.10	0.9	3.06	0.8	0.72	25.0	18.0	1.7
0.5	1.10	0.9	3.65	0.4	0.36	25.0	9.0	2.0
0.5	1.00	0.8	3.13	0.7	0.56	25.0	14.0	1.6
0.5	1.00	0.8	3.31	0.6	0.48	25.0	12.0	1.7
0.5	0.90	0.6	3.43	0.5	0.3	25.0	7.5	1.5
0.5	0.85	0.5	3.65	0.4	0.2	25.0	5.0	1.6
0.5	0.8	0.4	3.06	0.8	0.32	25.0	8.0	1.2
0.5	0.8	0.4	4.26	0	0	25.0	0.0	1.7
0.5	0.7	0.3	3.89	0.2	0.06	25.0	1.5	1.4
0.5	0.65	0.3	3.43	0.5	0.15	25.0	3.8	1.1
0.5	0.50	0.1	3.06	0.8	0.08	25.0	2.0	0.8
0.5	0.45	0.1	3.57	0.5	0.05	25.0	1.3	0.8
0.25	0.5	0.1	2.5	0.9	0.09	12.5	1.1	0.3
						400.0	134.9	22.1

3+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.5	0.00	0	0.00	0	0	25.0	0.0	0.0
0.75	0.60	0.2	3.19	0.7	0.14	37.5	5.3	1.4
0.5	0.70	0.3	2.92	0.9	0.27	25.0	6.8	1.0
0.5	0.90	0.6	2.74	0.9	0.54	25.0	13.5	1.2
0.5	0.90	0.6	3.43	0.5	0.3	25.0	7.5	1.5
0.5	0.90	0.6	3.84	0.2	0.12	25.0	3.0	1.7
0.5	1.00	0.8	3.98	0.2	0.16	25.0	4.0	2.0
0.5	1.10	0.9	3.98	0.2	0.18	25.0	4.5	2.2
0.5	1.15	0.9	3.89	0.2	0.18	25.0	4.5	2.2
0.5	1.10	0.9	3.72	0.3	0.27	25.0	6.8	2.0
0.5	1.1	0.9	3.98	0.2	0.18	25.0	4.5	2.2
0.5	1.1	0.9	3.89	0.2	0.18	25.0	4.5	2.1
0.5	0.8	0.4	4.07	0.1	0.04	25.0	1.0	1.6
0.5	0.8	0.4	2.74	0.9	0.36	25.0	9.0	1.1
0.75	0.65	0.3	0.69	0	0	37.5	0.0	0.3
1.5	0.35	0.1	2.20	0.8	0.08	75.0	6.0	1.2
1	0	0	0	0	0	50.0	0.0	0.0
						525.0	80.8	24.0

3+50 RL= 55

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1	1.10	0.9	0.11	0	0	55.0	0.0	0.1
1.25	1.50	0.8	0.21	0	0	68.8	0.0	0.4
0.5	1.40	0.9	0.18	0	0	27.5	0.0	0.1
0.5	1.30	0.9	0.16	0	0	27.5	0.0	0.1
0.5	1.20	0.9	0.19	0	0	27.5	0.0	0.1
0.5	1.20	0.9	0.57	0	0	27.5	0.0	0.3
0.5	1.30	0.9	1.23	0.2	0.18	27.5	5.0	0.8
0.5	1.30	0.9	1.51	0.4	0.36	27.5	9.9	1.0
0.5	1.40	0.9	2.00	0.7	0.63	27.5	17.3	1.4
0.5	1.50	0.8	1.96	0.6	0.48	27.5	13.2	1.5
0.5	1.7	0.5	2.15	0.8	0.4	27.5	11.0	1.8
0.5	1.85	0.1	2.55	0.9	0.09	27.5	2.5	2.4
0.5	2	0	2.99	0.9	0	27.5	0.0	3.0
0.5	2.05	0	3.65	0.4	0	27.5	0.0	3.7
0.5	2	0	3.24	0.7	0	27.5	0.0	3.2
0.5	2	0	2.05	0.7	0	27.5	0.0	2.1
0.75	0.9	0.6	1.35	0.2	0.12	41.3	5.0	0.9
0.5	0.8	0.4	0.68	0	0	27.5	0.0	0.3
						577.5	63.8	23.2

4+10 RL= 45

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.75	0.00	0	0.00	0	0	33.8	0.0	0.0
1	0.80	0.4	0.70	0	0	45.0	0.0	0.6
0.5	1.15	0.9	0.75	0	0	22.5	0.0	0.4
0.5	1.10	0.9	0.75	0	0	22.5	0.0	0.4
0.5	1.30	0.9	0.57	0	0	22.5	0.0	0.4
0.5	1.50	0.8	0.57	0	0	22.5	0.0	0.4
0.5	1.60	0.7	0.64	0	0	22.5	0.0	0.5
0.5	1.80	0.3	0.71	0	0	22.5	0.0	0.6
0.5	1.90	0.1	0.80	0	0	22.5	0.0	0.8
0.5	1.90	0.1	0.95	0.1	0.01	22.5	0.2	0.9
0.5	2.2	0	1.06	0.1	0	22.5	0.0	1.2
0.5	2.30	0	1.38	0.2	0	22.5	0.0	1.6
0.5	2.3	0	1.58	0.4	0	22.5	0.0	1.8
0.5	2.4	0	1.92	0.6	0	22.5	0.0	2.3
0.5	2.5	0	1.92	0.6	0	22.5	0.0	2.4
0.5	2.3	0	1.84	0.6	0	22.5	0.0	2.1
0.5	2.3	0	1.62	0.4	0	22.5	0.0	1.9
0.5	2.3	0	1.58	0.4	0	22.5	0.0	1.8
0.5	2.2	0	1.54	0.4	0	22.5	0.0	1.7
0.5	2.15	0	1.38	0.2	0	22.5	0.0	1.5
0.5	2	0	1.11	0.1	0	22.5	0.0	1.1
0.5	1.8	0.3	0.83	0	0	22.5	0.0	0.7
1.25	1.7	0.5	0.75	0	0	56.3	0.0	1.6
1	0	0	0	0	0	45.0	0.0	0.0
						630.0	0.2	26.7

4+40 RL= 44

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.5	0.00	0	0.00	0	0	22.0	0.0	0.0
1	1.00	0.8	0.26	0	0	44.0	0.0	0.3
1	1.30	0.9	0.29	0	0	44.0	0.0	0.4
0.75	1.50	0.8	0.97	0.1	0.08	33.0	2.6	1.1
0.5	1.50	0.8	1.35	0.2	0.16	22.0	3.5	1.0
0.5	1.40	0.9	1.47	0.3	0.27	22.0	5.9	1.0
0.5	1.50	0.8	1.41	0.3	0.24	22.0	5.3	1.1
0.5	1.50	0.8	1.76	0.5	0.4	22.0	8.8	1.3
0.5	1.40	0.9	1.92	0.6	0.54	22.0	11.9	1.3
0.5	1.50	0.8	2.00	0.7	0.56	22.0	12.3	1.5
0.5	1.4	0.9	2.15	0.8	0.72	22.0	15.8	1.5
0.5	1.40	0.9	2.34	0.9	0.81	22.0	17.8	1.6
0.5	1.3	0.9	2.15	0.8	0.72	22.0	15.8	1.4
0.5	1.3	0.9	2.1	0.8	0.72	22.0	15.8	1.4
0.5	1.3	0.9	2	0.7	0.63	22.0	13.9	1.3
0.5	1.1	0.9	1.67	0.4	0.36	22.0	7.9	0.9
0.5	1.1	0.9	1.65	0.4	0.36	22.0	7.9	0.9
0.5	1	0.8	1.35	0.2	0.16	22.0	3.5	0.7
0.5	0.9	0.6	1.11	0.1	0.06	22.0	1.3	0.5
0.5	0.9	0.6	1.03	0.1	0.06	22.0	1.3	0.5
0.5	0.9	0.6	0.79	0	0	22.0	0.0	0.4
0.75	0.8	0.4	0.77	0	0	33.0	0.0	0.5
1	0.8	0.4	0.49	0	0	44.0	0.0	0.4
1	0.8	0.4	0.57	0	0	44.0	0.0	0.5
1	0.8	0.4	0.72	0	0	44.0	0.0	0.6
1	0.8	0.4	0.97	0.1	0.04	44.0	1.8	0.8
1	0.8	0.4	1.06	0.1	0.04	44.0	1.8	0.8
1	0.7	0.3	0.91	0.1	0.03	44.0	1.3	0.6
2.5	0.7	0.3	0.62	0	0	110.0	0.0	1.1
2	0	0	0	0	0	88.0	0.0	0.0
						1012.0	156.4	25.2
						6073.0	969.1	229.6
							0.16	23.0

6-22-89

0+07 RL= 29

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.5	0.00	0	0.00	0	0	14.5	0.0	0.0
0.75	0.50	0.1	2.61	0.9	0.09	21.8	2.0	1.0
0.5	0.65	0.3	2.50	0.9	0.27	14.5	3.9	0.8
0.5	0.70	0.3	2.20	0.8	0.24	14.5	3.5	0.8
0.5	0.75	0.4	2.05	0.7	0.28	14.5	4.1	0.8
0.5	0.80	0.4	1.96	0.6	0.24	14.5	3.5	0.8
0.5	0.90	0.6	1.25	0.2	0.12	14.5	1.7	0.6
0.5	1.00	0.8	1.35	0.2	0.16	14.5	2.3	0.7
0.5	1.15	0.9	1.33	0.2	0.18	14.5	2.6	0.8
0.5	1.20	0.9	1.03	0.1	0.09	14.5	1.3	0.6
0.5	1.35	0.9	0.93	0.1	0.09	14.5	1.3	0.6
0.5	1.40	0.9	1.76	0.5	0.45	14.5	6.5	1.2
1	0.50	0.1	0.97	0.1	0.01	29.0	0.3	0.5
0.75	0.00	0	0.00	0	0	21.8	0.0	0.0
						232.0	33.0	9.1

0+50 RL= 46

W	D	SI	V	SI	SI*SI	T A	WT A	Q
2	0.00	0	0.00	0	0	92.0	0.0	0.0
2.5	1.20	0.9	0.03	0	0	115.0	0.0	0.1
0.75	0.90	0.6	0.23	0	0	34.5	0.0	0.2
0.5	1.30	0.9	0.35	0	0	23.0	0.0	0.2
0.5	1.40	0.9	0.34	0	0	23.0	0.0	0.2
0.5	1.30	0.9	0.97	0.1	0.09	23.0	2.1	0.6
0.5	1.25	0.9	1.41	0.3	0.27	23.0	6.2	0.9
0.5	1.20	0.9	2.00	0.7	0.63	23.0	14.5	1.2
0.5	1.20	0.9	2.00	0.7	0.63	23.0	14.5	1.2
0.5	1.15	0.9	2.00	0.7	0.63	23.0	14.5	1.2
0.5	1.10	0.9	2.39	0.9	0.81	23.0	18.6	1.3
0.5	1.10	0.9	1.76	0.5	0.45	23.0	10.4	1.0
3.75	1	0.8	4.9	0	0	172.5	0.0	18.4
3.5	0	0	0	0	0	161.0	0.0	0.0
						782.0	80.7	26.4

1+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.00	0	0.00	0	0	12.5	0.0	0.0
0.5	0.60	0.2	0.15	0	0	25.0	0.0	0.0
0.5	0.60	0.2	0.54	0	0	25.0	0.0	0.2
0.5	0.60	0.2	1.25	0.2	0.04	25.0	1.0	0.4
0.5	0.75	0.4	2.20	0.8	0.32	25.0	8.0	0.8
0.5	0.80	0.4	2.34	0.9	0.36	25.0	9.0	0.9
0.5	0.90	0.6	2.39	0.9	0.54	25.0	13.5	1.1
0.5	0.90	0.6	1.76	0.5	0.3	25.0	7.5	0.8
0.5	0.80	0.4	2.00	0.7	0.28	25.0	7.0	0.8
0.5	0.70	0.3	1.80	0.6	0.18	25.0	4.5	0.6
0.5	0.60	0.2	1.88	0.6	0.12	25.0	3.0	0.6
0.5	0.60	0.2	2.44	0.9	0.18	25.0	4.5	0.7
0.5	0.60	0.2	2.68	0.9	0.18	25.0	4.5	0.8
0.5	0.70	0.3	2.20	0.8	0.24	25.0	6.0	0.8
0.5	0.70	0.3	2.10	0.8	0.24	25.0	6.0	0.7
0.75	0.50	0.1	1.24	0.2	0.02	37.5	0.8	0.5
0.5	0	0	0	0	0	25.0	0.0	0.0
						425.0	75.3	9.7

1+50 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.35	0.1	0.20	0	0	12.5	0.0	0.0
0.5	0.50	0.1	0.40	0	0	25.0	0.0	0.1
0.5	0.60	0.2	0.48	0	0	25.0	0.0	0.1
0.5	0.60	0.2	1.35	0.2	0.04	25.0	1.0	0.4
0.5	0.70	0.3	2.05	0.7	0.21	25.0	5.2	0.7
0.5	0.70	0.3	2.55	0.9	0.27	25.0	6.8	0.9
0.5	0.70	0.3	2.20	0.8	0.24	25.0	6.0	0.8
0.5	0.70	0.3	2.20	0.8	0.24	25.0	6.0	0.8
0.5	0.70	0.3	2.34	0.9	0.27	25.0	6.8	0.8
0.5	0.60	0.2	2.39	0.9	0.18	25.0	4.5	0.7
0.5	0.60	0.2	2.34	0.9	0.18	25.0	4.5	0.7
0.5	0.60	0.2	1.88	0.6	0.12	25.0	3.0	0.6
0.5	0.50	0.1	1.41	0.3	0.03	25.0	0.8	0.4
0.5	0.50	0.1	1.08	0.1	0.01	25.0	0.3	0.3
1	0.30	0	0.89	0	0	50.0	0.0	0.3
0.75	0	0	0	0	0	37.5	0.0	0.0
						425.0	44.8	7.5

2+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
3	0.00	0	0.00	0	0	150.0	0.0	0.0
3.25	0.40	0.1	1.88	0.6	0.06	162.5	9.8	2.4
0.5	0.50	0.1	0.73	0	0	25.0	0.0	0.2
0.5	0.50	0.1	2.29	0.8	0.08	25.0	2.0	0.6
0.5	0.50	0.1	2.34	0.9	0.09	25.0	2.3	0.6
0.5	0.60	0.2	1.96	0.6	0.12	25.0	3.0	0.6
0.5	0.60	0.2	2.00	0.7	0.14	25.0	3.5	0.6
0.5	0.70	0.3	2.86	0.9	0.27	25.0	6.8	1.0
0.5	0.60	0.2	2.61	0.9	0.18	25.0	4.5	0.8
0.5	0.60	0.2	3.06	0.8	0.16	25.0	4.0	0.9
0.5	0.60	0.2	2.92	0.9	0.18	25.0	4.5	0.9
0.5	0.4	0.1	2.61	0.9	0.09	25.0	2.3	0.5
0.75	0.40	0.1	1.47	0.3	0.03	37.5	1.1	0.4
0.5	0	0	0	0	0	25.0	0.0	0.0
						625.0	43.6	9.5

2+50 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	1.00	0.8	0.43	0	0	12.5	0.0	0.1
0.5	1.00	0.8	0.86	0	0	25.0	0.0	0.4
0.5	0.90	0.6	2.29	0.8	0.48	25.0	12.0	1.0
0.5	0.90	0.6	2.05	0.7	0.42	25.0	10.5	0.9
0.5	0.80	0.4	2.55	0.9	0.36	25.0	9.0	1.0
0.5	0.60	0.2	2.74	0.9	0.18	25.0	4.5	0.8
0.5	0.50	0.1	2.55	0.9	0.09	25.0	2.3	0.6
0.5	0.50	0.1	3.57	0.5	0.05	25.0	1.3	0.9
0.5	0.40	0.1	1.88	0.6	0.06	25.0	1.5	0.4
0.5	0.35	0.1	1.84	0.6	0.06	25.0	1.5	0.3
0.75	0.30	0	2.39	0.9	0	37.5	0.0	0.5
1.5	0.40	0.1	2.80	0.9	0.09	75.0	6.8	1.7
1	0	0	0	0	0	50.0	0.0	0.0
						400.0	49.3	8.8

3+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.5	0.00	0	0.00	0	0	25.0	0.0	0.0
0.75	0.40	0.1	1.67	0.4	0.04	37.5	1.5	0.5
0.5	0.40	0.1	1.84	0.6	0.06	25.0	1.5	0.4
0.5	0.50	0.1	2.55	0.9	0.09	25.0	2.3	0.6
0.5	0.50	0.1	1.92	0.6	0.06	25.0	1.5	0.5
0.5	0.60	0.2	2.24	0.8	0.16	25.0	4.0	0.7
0.5	0.60	0.2	2.68	0.9	0.18	25.0	4.5	0.8
0.5	0.60	0.2	2.68	0.9	0.18	25.0	4.5	0.8
0.5	0.65	0.3	2.50	0.9	0.27	25.0	6.8	0.8
0.5	0.60	0.2	2.50	0.9	0.18	25.0	4.5	0.8
0.5	0.6	0.2	2.5	0.9	0.18	25.0	4.5	0.8
0.5	0.65	0.3	2.5	0.9	0.27	25.0	6.8	0.8
0.5	0.60	0.2	2.34	0.9	0.18	25.0	4.5	0.7
0.25	0.6	0.2	1.17	0.1	0.02	12.5	0.3	0.2
						350.0	47.0	8.3

3+50 RL= 55

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.5	0.00	0	0.00	0	0	27.5	0.0	0.0
0.75	0.90	0.6	0.12	0	0	41.3	0.0	0.1
0.5	0.80	0.4	0.24	0	0	27.5	0.0	0.1
0.5	0.70	0.3	0.26	0	0	27.5	0.0	0.1
0.5	0.70	0.3	0.48	0	0	27.5	0.0	0.2
0.5	0.65	0.3	1.28	0.2	0.06	27.5	1.7	0.4
0.5	0.60	0.2	1.23	0.2	0.04	27.5	1.1	0.4
0.5	0.60	0.2	0.83	0	0	27.5	0.0	0.2
0.5	0.70	0.3	0.50	0	0	27.5	0.0	0.2
0.5	0.80	0.4	0.42	0	0	27.5	0.0	0.2
0.5	0.9	0.6	0.41	0	0	27.5	0.0	0.2
0.5	1.10	0.9	0.60	0	0	27.5	0.0	0.3
0.5	1.2	0.9	0.81	0	0	27.5	0.0	0.5
0.5	1.3	0.9	1.08	0.1	0.09	27.5	2.5	0.7
0.5	1.4	0.9	1.47	0.3	0.27	27.5	7.4	1.0
0.5	1.4	0.9	1.84	0.6	0.54	27.5	14.9	1.3
1	1.4	0.9	1.58	0.4	0.36	55.0	19.8	2.2
0.75	0	0	0	0	0	41.3	0.0	0.0
						550.0	47.3	8.0

4+10 RL= 45

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1	0.00	0	0.00	0	0	45.0	0.0	0.0
1.5	0.80	0.4	0.41	0	0	67.5	0.0	0.5
1	1.00	0.8	0.42	0	0	45.0	0.0	0.4
0.75	1.05	0.8	0.70	0	0	33.8	0.0	0.6
0.75	1.20	0.9	0.55	0	0	33.8	0.0	0.5
0.5	1.50	0.8	0.64	0	0	22.5	0.0	0.5
0.5	1.50	0.8	0.65	0	0	22.5	0.0	0.5
0.5	1.70	0.5	0.89	0	0	22.5	0.0	0.8
0.5	1.80	0.3	1.03	0.1	0.03	22.5	0.7	0.9
0.5	1.80	0.3	1.11	0.1	0.03	22.5	0.7	1.0
0.5	1.9	0.1	1.28	0.2	0.02	22.5	0.5	1.2
0.5	1.80	0.3	1.51	0.4	0.12	22.5	2.7	1.4
0.5	1.8	0.3	1.62	0.4	0.12	22.5	2.7	1.5
0.5	1.7	0.5	1.25	0.2	0.1	22.5	2.3	1.1
0.5	1.6	0.7	1.06	0.1	0.07	22.5	1.6	0.8
0.5	1.6	0.7	0.83	0	0	22.5	0.0	0.7
0.75	1.3	0.9	0.55	0	0	33.8	0.0	0.5
1.5	1.2	0.9	0.29	0	0	67.5	0.0	0.5
1	0	0	0	0	0	45.0	0.0	0.0
						618.8	11.0	13.3

4+40 RL= 44

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1	0.00	0	0.00	0	0	44.0	0.0	0.0
1.25	0.90	0.6	0.72	0	0	55.0	0.0	0.8
0.5	0.90	0.6	0.91	0.1	0.06	22.0	1.3	0.4
0.5	0.90	0.6	0.97	0.1	0.06	22.0	1.3	0.4
0.5	0.80	0.4	1.15	0.1	0.04	22.0	0.9	0.5
0.5	0.90	0.6	1.33	0.2	0.12	22.0	2.6	0.6
0.5	0.90	0.6	1.44	0.3	0.18	22.0	4.0	0.6
0.5	0.80	0.4	1.44	0.3	0.12	22.0	2.6	0.6
0.5	0.85	0.5	1.54	0.4	0.2	22.0	4.4	0.7
0.5	0.85	0.5	1.54	0.4	0.2	22.0	4.4	0.7
0.5	0.8	0.4	1.3	0.2	0.08	22.0	1.8	0.5
0.5	0.70	0.3	1.11	0.1	0.03	22.0	0.7	0.4
0.5	0.7	0.3	1.23	0.2	0.06	22.0	1.3	0.4
0.5	0.7	0.3	1.19	0.1	0.03	22.0	0.7	0.4
0.5	0.5	0.1	1.11	0.1	0.01	22.0	0.2	0.3
0.5	0.45	0.1	1.01	0.1	0.01	22.0	0.2	0.2
0.75	0.4	0.1	0.97	0.1	0.01	33.0	0.3	0.3
4	0.35	0.1	0.83	0	0	176.0	0.0	1.2
3.5	0	0	0	0	0	154.0	0.0	0.0
						770.0	26.7	9.0
						5177.8	458.6	109.6
							0.09	11.0

October 15, 1990
8M087.140/WPWATRES1719

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Mr. Bob Clark
Department of Natural Resources
& Conservation
Lee Metcalf Bldg.
1520 East 6th Avenue
Helena, MT 59620

RE: Middle Creek Dam Grayling Structure

Dear Bob:

Estimates of habitat available in the side channel downstream of the permanent grayling mitigation structure based on flow measurements taken in 1989 were provided to you in a letter dated January 16, 1990. Estimates based on 1990 measurements have been prepared and are submitted herein.

The DNRC made flow measurements in the side channel on May 30, June 10 and June 27, 1990. As with the 1989 results, spreadsheets for each of these measurements which estimate the amount of habitat in the side channel are attached.

The spreadsheets are arranged by station number (i.e. 0+50, 1+00, etc.). RL stands for each length, which equals the sum of half the distance to the next upstream and downstream sections. Columns in the spreadsheet are as follows:

Column W - Incremental channel width in feet
Column D - Water depth in feet in each increment of the channel
Column SI - Suitability Index for depth from Fernet's 1987 report, see attached SI curve
Column V - Average velocity in fps in each increment of the channel
Column SI - Suitability Index for velocity from Fernet's 1987 report, see attached SI curve
Column SI*SI - Product of the two SI values
Column TA - Total area in sq. ft. or RL*W in each increment of the channel
Column WT A - Weighted area in sq. ft. or SI*SI*RL*W in each increment of the channel
Column Q - Flow in cfs in each increment of the channel or W*D*V

The results of this analysis are presented in the following table. Results from 1986 (Reach 1) and 1989 are included for comparison purposes. It should be noted that the corner of the diversion structure was reinforced in the fall of 1989 to bring the flow distribution back closer to the original design, therefore, the flow in the side channel relative to flow in the creek is higher in 1990 than in 1989. It is also noted that the spreadsheet has been updated to interpolate SI values. SI values for 1989 were read from the curves manually and rounded to one-tenth increments.

	Area in sq. ft.				Total Good &	Side Channel Q	Total Q
Date	Excellent	Good	Marginal	Total	Excellent	in cfs	in cfs
1986 (Reach 1)[4/]	348	736	2748	3832	1084		
1987 (V Structure)[5/]	270	885			1155		
5/16/89	231[1/]	1122[2/]	1809[3/]	3169	1360	13.1	43
6/15/89	454[1/]	1198[2/]	1854[3/]	3506	1652	23.0	109
6/22/89	92[1/]	653[2/]	1940[3/]	2685	745	11.0	75
5/30/90	765[1/]	1981[2/]	2601[3/]	5347	2746	24.3	93
6/10/90	750[1/]	1475[2/]	3343[3/]	5568	2225	30.1	127
6/27/90	948[1/]	1466[2/]	2782[3/]	5196	2414	28.4	124

1/ Greater than or equal to SI*SI = .63 (.9*.7).
2/ Greater than or equal to SI*SI = .24 (.6*.4).
3/ Greater than SI*SI = 0.
4/ Included to show that habitat in side channel exceeds habitat available in Reach 1 during 1986.
5/ Structure constructed in 1987 to test habitat enhancement methods.

Flows of 124 and 127 cfs are approximately equal to the estimated bank full discharge of 140 cfs. A flow of 93 cfs is slightly higher than the design low flow of 82 cfs. The amount of Excellent, Good, Good and Excellent, and Total area exceeds that identified in Reach 1 in 1986. Modifications of the diversion structure brought flows in the side channel back closer to design levels and significantly increased the amount of good and excellent habitat.

The hydraulics of the side channel are now very satisfactory, however, it must be remembered that Arctic grayling will probably not use the side channel until the reservoir is raised. The amount of habitat downstream of the side channel makes travel upstream to the side channel unnecessary.

If you have any questions, feel free to call.

Sincerely,

HKM ASSOCIATES

Gary E Elwell

Gary E. Elwell, P.E.

GEE/cc

Attachment

Figure 9. Habitat utilization curve and histogram, depth in feet 1986 and 1987 data.

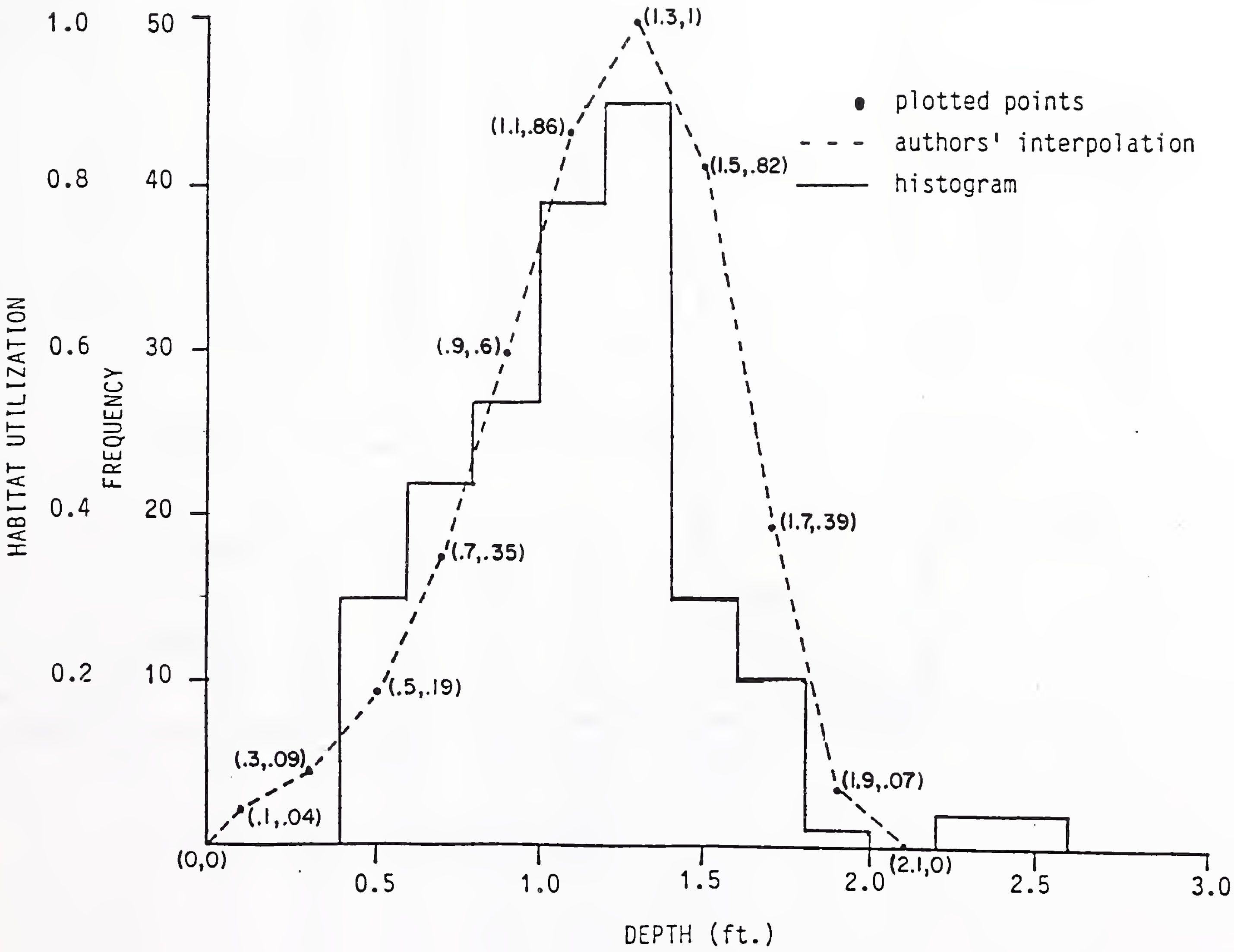
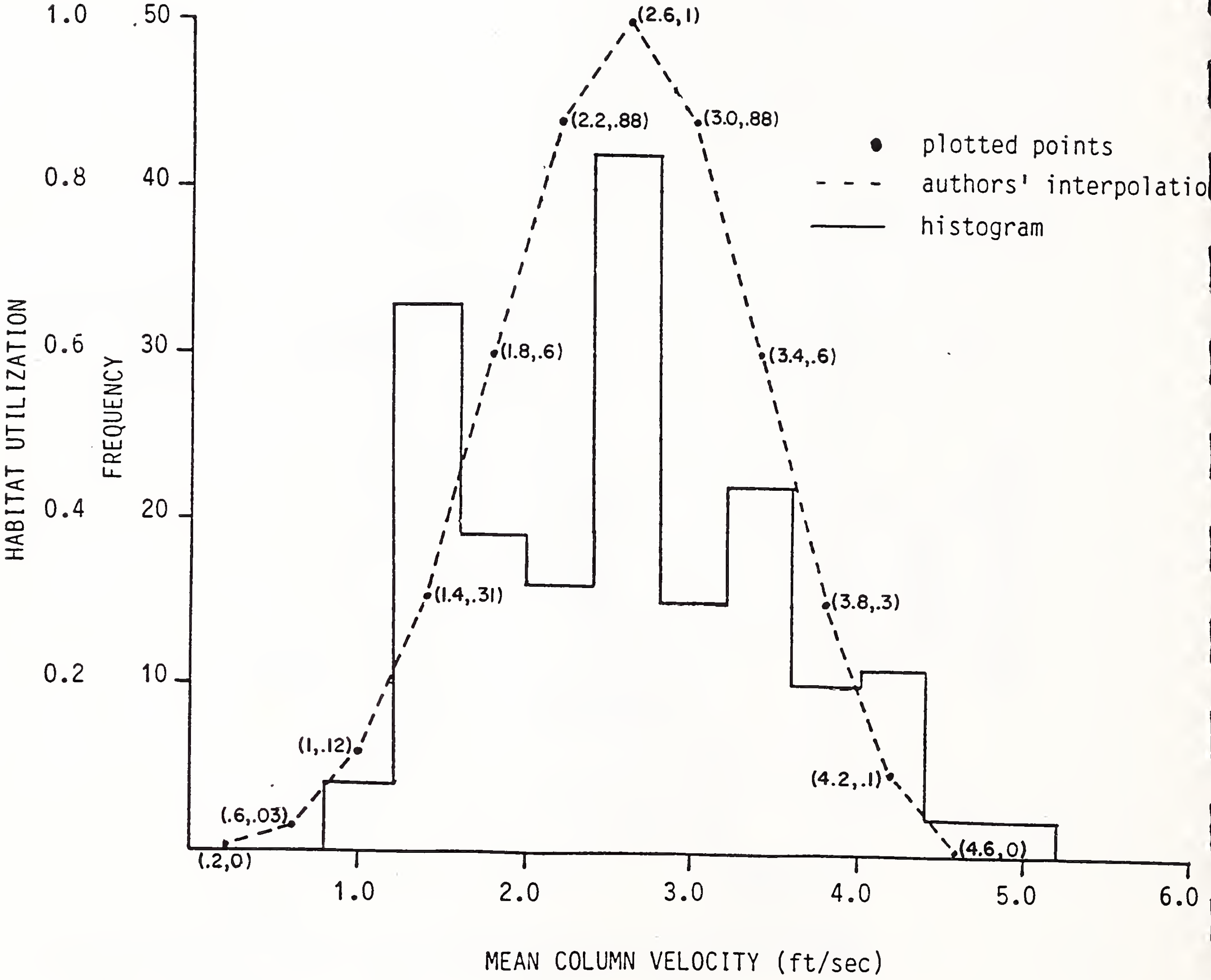


Figure 10. Habitat utilization curve and histogram, mean column velocity in cm/sec, 1986 and 1987 data.



5-30-90

0+07 RL= 29

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1.5	0.00	0	0.00	0.00	0.00	43.5	0.0	0.0
2.5	0.3	0.09	0.57	0.03	0.00	72.5	0.2	0.4
1.5	0.9	0.6	0.38	0.01	0.01	43.5	0.4	0.5
0.75	1	0.73	0.38	0.01	0.01	21.8	0.2	0.3
0.5	1	0.73	0.55	0.03	0.02	14.5	0.3	0.3
0.5	1.1	0.86	0.88	0.09	0.08	14.5	1.2	0.5
0.5	1.15	0.895	1.15	0.19	0.17	14.5	2.5	0.7
0.5	1.2	0.93	1.33	0.28	0.26	14.5	3.7	0.8
0.5	1.15	0.895	1.33	0.28	0.25	14.5	3.6	0.8
0.5	1.2	0.93	1.65	0.49	0.46	14.5	6.6	1.0
0.5	1.3	1	1.8	0.60	0.60	14.5	8.7	1.2
0.5	1.3	1	2.05	0.77	0.77	14.5	11.2	1.3
0.5	1.3	1	1.51	0.39	0.39	14.5	5.7	1.0
0.5	1.4	0.91	2.05	0.77	0.71	14.5	10.2	1.4
0.5	1.35	0.955	2.05	0.77	0.74	14.5	10.7	1.4
0.5	1.5	0.82	2.1	0.81	0.66	14.5	9.6	1.6
0.5	1.5	0.82	2.1	0.81	0.66	14.5	9.6	1.6
0.5	1.55	0.7125	2.29	0.91	0.65	14.5	9.4	1.8
0.5	1.6	0.605	1.73	0.55	0.33	14.5	4.8	1.4
0.5	1.7	0.39	2.2	0.88	0.34	14.5	5.0	1.9
0.5	1.75	0.31	2.2	0.88	0.27	14.5	4.0	1.9
0.25	1.6	0.605	1.54	0.41	0.25	7.3	1.8	0.6
0	0.00	0	0.00	0.00	0.00	0.0	0.0	0.0
						435.0	109.3	22.2

0+50 RL= 46

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1.5	0.60	0.27	0.00	0.00	0.00	69.0	0.0	0.0
1.75	1.3	1	0.75	0.06	0.06	80.5	5.1	1.7
0.5	1.8	0.23	0.73	0.06	0.01	23.0	0.3	0.7
0.5	1.9	0.07	0.72	0.06	0.00	23.0	0.1	0.7
0.5	1.85	0.15	1.01	0.12	0.02	23.0	0.4	0.9
0.5	1.7	0.39	2.15	0.84	0.33	23.0	7.6	1.8
0.5	1.5	0.82	1.92	0.68	0.56	23.0	12.9	1.4
0.5	1.5	0.82	1.8	0.60	0.49	23.0	11.3	1.4
0.5	1.5	0.82	3.13	0.79	0.65	23.0	14.9	2.3
0.5	1.3	1	2.69	0.97	0.97	23.0	22.4	1.7
0.5	1.2	0.93	2.05	0.77	0.72	23.0	16.6	1.2
0.5	1.2	0.93	1.08	0.16	0.15	23.0	3.4	0.6
0.5	1.2	0.93	1.17	0.20	0.19	23.0	4.3	0.7
0.5	1.2	0.93	1.63	0.48	0.44	23.0	10.2	1.0
0.5	1.1	0.86	1.51	0.39	0.34	23.0	7.7	0.8
2.25	1.2	0.93	1.35	0.29	0.27	103.5	27.6	3.6
5	0.5	0.19	1.41	0.32	0.06	230.0	13.9	3.5
3	0.00	0	0.00	0.00	0.00	138.0	0.0	0.0
						920.0	158.6	24.3

15-Oct-90

1+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.00	0	0.00	0.00	0.00	12.5	0.0	0.0
0.5	1	0.73	2.58	0.99	0.73	25.0	18.1	1.3
0.5	1	0.73	2.69	0.97	0.71	25.0	17.8	1.3
0.5	1.05	0.795	3.28	0.68	0.54	25.0	13.6	1.7
0.75	1	0.73	3.28	0.68	0.50	37.5	18.7	2.5
0.75	1.1	0.86	5.08	0.00	0.00	37.5	0.0	4.2
0.5	1.05	0.795	4.37	0.06	0.05	25.0	1.1	2.3
0.5	1	0.73	3.72	0.36	0.26	25.0	6.6	1.9
0.5	0.9	0.6	3.5	0.52	0.31	25.0	7.9	1.6
0.5	1	0.73	3.06	0.84	0.61	25.0	15.3	1.5
0.5	1.1	0.86	2.92	0.90	0.78	25.0	19.4	1.6
0.5	1	0.73	2.5	0.97	0.71	25.0	17.7	1.3
0.5	1.1	0.86	3.06	0.84	0.72	25.0	18.0	1.7
0.5	0.95	0.665	3.28	0.68	0.45	25.0	11.4	1.6
0.5	0.8	0.475	2.55	0.98	0.47	25.0	11.7	1.0
1	0.7	0.35	1.38	0.30	0.11	50.0	5.3	1.0
0.75	0	0	0	0.00	0.00	37.5	0.0	0.0
0	0.00	0	0.00	0.00	0.00	0.0	0.0	0.0
						475.0	182.6	26.4

1+50 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1.25	0.00	0	0.00	0.00	0.00	62.5	0.0	0.0
1.5	1.1	0.86	1.2	0.22	0.18	75.0	13.9	2.0
0.5	1.2	0.93	1.76	0.57	0.53	25.0	13.3	1.1
0.5	1.2	0.93	2.74	0.96	0.89	25.0	22.3	1.6
0.5	1.3	1	3.5	0.52	0.52	25.0	13.1	2.3
0.5	1.2	0.93	3.65	0.41	0.38	25.0	9.6	2.2
0.5	1.1	0.86	3.28	0.68	0.59	25.0	14.7	1.8
0.5	1.1	0.86	3.13	0.79	0.68	25.0	17.0	1.7
0.5	1.1	0.86	3.37	0.62	0.53	25.0	13.4	1.9
0.5	1.1	0.86	3.8	0.30	0.26	25.0	6.4	2.1
0.5	1	0.73	3.57	0.47	0.34	25.0	8.6	1.8
0.5	0.9	0.6	3.5	0.52	0.31	25.0	7.9	1.6
0.5	0.8	0.475	2.92	0.90	0.43	25.0	10.7	1.2
0.5	0.75	0.4125	2.39	0.94	0.39	25.0	9.7	0.9
0.5	0.7	0.35	2.44	0.95	0.33	25.0	8.3	0.9
0.5	0.7	0.35	2.1	0.81	0.28	25.0	7.1	0.7
0.5	0.6	0.27	1.28	0.25	0.07	25.0	1.7	0.4
1.5	0.5	0.19	1.65	0.49	0.09	75.0	7.0	1.2
1.25	0	0	0	0.00	0.00	62.5	0.0	0.0
0	0.00	0	0.00	0.00	0.00	0.0	0.0	0.0
						650.0	184.6	25.2

GRAY530

2+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.50	0.19	0.56	0.03	0.01	12.5	0.1	0.1
0.5	0.6	0.27	1.11	0.17	0.05	25.0	1.2	0.3
0.5	0.5	0.19	1.17	0.20	0.04	25.0	1.0	0.3
0.5	0.4	0.14	1.11	0.17	0.02	25.0	0.6	0.2
0.5	0.35	0.115	1.23	0.23	0.03	25.0	0.7	0.2
0.5	0.4	0.14	1.51	0.39	0.05	25.0	1.4	0.3
0.5	0.4	0.14	1.35	0.29	0.04	25.0	1.0	0.3
0.5	0.4	0.14	1.06	0.15	0.02	25.0	0.5	0.2
0.5	0.4	0.14	2.15	0.84	0.12	25.0	3.0	0.4
0.5	0.4	0.14	1.92	0.68	0.10	25.0	2.4	0.4
0.5	0.4	0.14	2.44	0.95	0.13	25.0	3.3	0.5
0.5	0.5	0.19	2.29	0.91	0.17	25.0	4.3	0.6
0.5	0.7	0.35	3.5	0.52	0.18	25.0	4.6	1.2
0.5	0.8	0.475	3.06	0.84	0.40	25.0	10.0	1.2
0.5	0.9	0.6	3.28	0.68	0.41	25.0	10.3	1.5
0.5	0.9	0.6	3.06	0.84	0.50	25.0	12.6	1.4
0.5	1	0.73	2.92	0.90	0.66	25.0	16.5	1.5
0.5	1	0.73	3.5	0.52	0.38	25.0	9.6	1.8
0.5	0.9	0.6	3.8	0.30	0.18	25.0	4.5	1.7
0.5	0.95	0.665	4.07	0.16	0.11	25.0	2.7	1.9
0.5	1	0.73	4.37	0.06	0.04	25.0	1.0	2.2
0.5	1	0.73	4.26	0.09	0.06	25.0	1.6	2.1
1.75	0.9	0.6	3.65	0.41	0.25	87.5	21.7	5.7
1.5	0.8	0.475	1.18	0.21	0.10	75.0	7.3	1.4
1	0.00	0	0.00	0.00	0.00	50.0	0.0	0.0
						750.0	121.6	27.4

2+50 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	1.20	0.93	1.20	0.22	0.20	12.5	2.5	0.4
0.5	1.3	1	2.39	0.94	0.94	25.0	23.4	1.6
0.5	1.2	0.93	1.73	0.55	0.51	25.0	12.8	1.0
0.5	1	0.73	2.99	0.88	0.64	25.0	16.1	1.5
0.5	0.9	0.6	2.74	0.96	0.57	25.0	14.4	1.2
0.5	1	0.73	2.74	0.96	0.70	25.0	17.5	1.4
0.5	0.8	0.475	3.5	0.52	0.25	25.0	6.2	1.4
0.5	0.9	0.6	2.99	0.88	0.53	25.0	13.2	1.3
0.5	0.9	0.6	3.8	0.30	0.18	25.0	4.5	1.7
0.5	0.75	0.4125	3.21	0.73	0.30	25.0	7.6	1.2
0.5	0.75	0.4125	3.65	0.41	0.17	25.0	4.3	1.4
0.5	0.8	0.475	4.26	0.09	0.04	25.0	1.0	1.7
0.5	0.8	0.475	3.28	0.68	0.32	25.0	8.1	1.3
0.5	0.8	0.475	3.89	0.25	0.12	25.0	3.0	1.6
0.5	0.8	0.475	2.92	0.90	0.43	25.0	10.7	1.2
0.75	0.7	0.35	3.5	0.52	0.18	37.5	6.9	1.8
0.5	0	0	0	0.00	0.00	25.0	0.0	0.0
0	0.00	0	0.00	0.00	0.00	0.0	0.0	0.0
						425.0	152.2	21.7

3+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.5	0.00	0	0.00	0.00	0.00	25.0	0.0	0.0
0.75	0.6	0.27	2.1	0.81	0.22	37.5	8.2	0.9
0.5	0.7	0.35	3.28	0.68	0.24	25.0	6.0	1.1
0.5	0.8	0.475	3.06	0.84	0.40	25.0	10.0	1.2
0.5	0.9	0.6	3.13	0.79	0.47	25.0	11.8	1.4
0.5	1	0.73	2.86	0.92	0.67	25.0	16.8	1.4
0.5	1.05	0.795	2.5	0.97	0.77	25.0	19.3	1.3
0.5	1.1	0.86	3.13	0.79	0.68	25.0	17.0	1.7
0.5	1.1	0.86	3.28	0.68	0.59	25.0	14.7	1.8
0.5	1.2	0.93	3.8	0.30	0.28	25.0	7.0	2.3
0.5	1.1	0.86	3.57	0.47	0.41	25.0	10.2	2.0
0.5	1	0.73	3.37	0.62	0.45	25.0	11.3	1.7
0.5	0.95	0.665	3.43	0.58	0.38	25.0	9.6	1.6
0.5	1	0.73	3.57	0.47	0.34	25.0	8.6	1.8
0.5	0.95	0.665	3.5	0.52	0.35	25.0	8.7	1.7
2.25	0.8	0.475	2.44	0.95	0.45	112.5	50.9	4.4
2	0	0	0	0.00	0.00	100.0	0.0	0.0
0	0.00	0	0.00	0.00	0.00	0.0	0.0	0.0
						600.0	210.0	26.4

3+50 RL= 55

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1	0.00	0	0.00	0.00	0.00	55.0	0.0	0.0
1.5	0.8	0.475	0.49	0.02	0.01	82.5	0.9	0.6
1	0.8	0.475	0.84	0.08	0.04	55.0	2.2	0.7
0.75	0.9	0.6	1.58	0.44	0.26	41.3	10.9	1.1
0.5	1	0.73	1.28	0.25	0.18	27.5	5.1	0.6
0.5	1.1	0.86	1.38	0.30	0.26	27.5	7.1	0.8
0.5	1.25	0.965	1.73	0.55	0.53	27.5	14.6	1.1
0.5	1.35	0.955	1.92	0.68	0.65	27.5	18.0	1.3
0.5	1.5	0.82	2.24	0.89	0.73	27.5	20.1	1.7
0.5	1.5	0.82	2.34	0.92	0.76	27.5	20.8	1.8
0.5	1.7	0.39	2.55	0.98	0.38	27.5	10.6	2.2
0.5	1.7	0.39	2	0.74	0.29	27.5	7.9	1.7
0.5	1.6	0.605	2.05	0.77	0.47	27.5	12.9	1.6
0.5	1.6	0.605	2.16	0.85	0.52	27.5	14.2	1.7
0.5	1.5	0.82	0.93	0.10	0.09	27.5	2.4	0.7
0.25	1.3	1	0.47	0.02	0.02	13.8	0.3	0.2
0	0.00	0	0.00	0.00	0.00	0.0	0.0	0.0
						550.0	147.8	17.6

4+10 RL= 45

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.75	0.00	0	0.00	0.00	0.00	33.8	0.0	0.0
1.25	1.1	0.86	1.11	0.17	0.15	56.3	8.3	1.5
1	1.3	1	1.08	0.16	0.16	45.0	7.1	1.4
1	1.2	0.93	0.91	0.10	0.09	45.0	4.2	1.1
1	1.2	0.93	0.89	0.10	0.09	45.0	4.0	1.1
1	1.4	0.91	1.11	0.17	0.16	45.0	7.1	1.6
0.75	1.7	0.39	1.51	0.39	0.15	33.8	5.1	1.9
0.5	1.9	0.07	1.92	0.68	0.05	22.5	1.1	1.8
0.5	1.9	0.07	1.84	0.63	0.04	22.5	1.0	1.7
0.5	2	0.035	2.15	0.84	0.03	22.5	0.7	2.2
0.5	2.1	0	2.08	0.80	0.00	22.5	0.0	2.2
0.5	2.1	0	1.88	0.66	0.00	22.5	0.0	2.0
0.5	2	0.035	1.65	0.49	0.02	22.5	0.4	1.7
0.5	1.8	0.23	1.67	0.51	0.12	22.5	2.6	1.5
0.5	1.8	0.23	1.35	0.29	0.07	22.5	1.5	1.2
0.75	1.7	0.39	1.33	0.28	0.11	33.8	3.6	1.7
1	1.5	0.82	0.91	0.10	0.08	45.0	3.7	1.4
1	1.1	0.86	0.43	0.02	0.01	45.0	0.7	0.5
0.5	0	0	0	0.00	0.00	22.5	0.0	0.0
0	0.00	0	0.00	0.00	0.00	0.0	0.0	0.0
						630.0	51.0	26.4

4+40 RL= 44

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.75	0.00	0	0.00	0.00	0.00	33.0	0.0	0.0
1.25	1.2	0.93	0.41	0.02	0.01	55.0	0.8	0.6
1	1.3	1	1.35	0.29	0.29	44.0	12.6	1.8
1	1.3	1	1.58	0.44	0.44	44.0	19.4	2.1
1	1.25	0.965	1.92	0.68	0.66	44.0	29.0	2.4
1	1.3	1	1.92	0.68	0.68	44.0	30.1	2.5
1	1.25	0.965	1.96	0.71	0.69	44.0	30.2	2.5
1	1.1	0.86	2.1	0.81	0.70	44.0	30.7	2.3
1	1	0.73	2.15	0.84	0.62	44.0	27.1	2.2
1	0.8	0.475	2.15	0.84	0.40	44.0	17.7	1.7
1	0.8	0.475	1.76	0.57	0.27	44.0	11.9	1.4
1	0.75	0.4125	1.54	0.41	0.17	44.0	7.5	1.2
1	0.7	0.35	1.38	0.30	0.11	44.0	4.6	1.0
1	0.6	0.27	1.28	0.25	0.07	44.0	3.0	0.8
1	0.65	0.31	1.19	0.21	0.07	44.0	2.9	0.8
1	0.6	0.27	1.21	0.22	0.06	44.0	2.6	0.7
1	0.5	0.19	1.11	0.17	0.03	44.0	1.4	0.6
2.5	0.5	0.19	1.11	0.17	0.03	110.0	3.6	1.4
2	0	0	0	0.00	0.00	88.0	0.0	0.0
0	0.00	0	0.00	0	0	0.0	0.0	0.0
						946.0	235.2	25.7
						6381	1552.96	243.21
							0.24	24.32

6-10-90

0+07 RL= 29

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1.5	0.00	0	0.00	0.00	0.00	43.5	0.0	0.0
1.75	0.4	0.14	1.06	0.15	0.02	50.8	1.1	0.7
1.75	0.4	0.14	1.08	0.16	0.02	50.8	1.1	0.8
2	1	0.73	0.53	0.02	0.02	58.0	1.0	1.1
1	1.1	0.86	0.64	0.04	0.03	29.0	1.0	0.7
0.75	1.2	0.93	1.11	0.17	0.16	21.8	3.5	1.0
0.5	1.3	1	1.73	0.55	0.55	14.5	8.0	1.1
0.5	1.4	0.91	2.2	0.88	0.80	14.5	11.6	1.5
0.5	1.5	0.82	2.34	0.92	0.76	14.5	11.0	1.8
0.5	1.55	0.71	2.39	0.94	0.67	14.5	9.7	1.9
0.5	1.5	0.82	2.61	1.00	0.82	14.5	11.9	2.0
0.5	1.65	0.50	2.74	0.96	0.48	14.5	6.9	2.3
0.5	1.8	0.23	2.74	0.96	0.22	14.5	3.2	2.5
0.5	1.9	0.07	3.65	0.41	0.03	14.5	0.4	3.5
0.5	2	0.04	3.43	0.58	0.02	14.5	0.3	3.4
0.5	2.1	0.00	3.37	0.62	0.00	14.5	0.0	3.5
0.25	2	0.04	2.36	0.93	0.03	7.3	0.2	1.2
0	0.00	0.00	0.00	0.00	0.00	0.0	0.0	0.0
						406.0	70.8	28.8

0+50 RL= 46.00

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1	0.00	0.00	0.00	0.00	0.00	46.0	0.0	0.0
1.25	1.2	0.93	0.68	0.05	0.04	57.5	2.6	1.0
0.5	1.3	1.00	0.91	0.10	0.10	23.0	2.3	0.6
0.5	1.5	0.82	1.41	0.32	0.26	23.0	6.0	1.1
0.5	1.6	0.60	1.73	0.55	0.33	23.0	7.6	1.4
0.5	2	0.04	2.2	0.88	0.03	23.0	0.7	2.2
0.5	2	0.04	1.73	0.55	0.02	23.0	0.4	1.7
0.5	1.8	0.23	1.51	0.39	0.09	23.0	2.1	1.4
0.5	1.6	0.60	0.74	0.06	0.04	23.0	0.9	0.6
0.5	1.6	0.60	1.96	0.71	0.43	23.0	9.9	1.6
0.5	1.6	0.60	2.74	0.96	0.58	23.0	13.3	2.2
0.5	1.5	0.82	2.99	0.88	0.72	23.0	16.7	2.2
0.5	1.4	0.91	2.24	0.89	0.81	23.0	18.7	1.6
0.5	1.4	0.91	2.15	0.84	0.77	23.0	17.7	1.5
0.5	1.3	1.00	2.15	0.84	0.84	23.0	19.4	1.4
0.5	1.2	0.93	2.2	0.88	0.82	23.0	18.8	1.3
0.5	1.2	0.93	2.15	0.84	0.79	23.0	18.1	1.3
1.75	1.2	0.93	1.73	0.55	0.51	80.5	41.1	3.6
2	0.5	0.19	1.11	0.17	0.03	92.0	3.0	1.1
1	0.8	0.48	2.39	0.94	0.45	46.0	20.5	1.9
1	0.6	0.27	1.96	0.71	0.19	46.0	8.8	1.2
3	0.4	0.14	1.08	0.16	0.02	138.0	3.1	1.3
2.5	0	0.00	0	0.00	0.00	115.0	0.0	0.0
0	0.00	0	0.00	0.00	0.00	0.0	0.0	0.0
						966.0	231.6	32.1

1+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.5	0.00	0	0.00	0.00	0.00	25.0	0.0	0.0
0.75	1.2	0.93	2.5	0.97	0.11	37.5	33.8	2.3
0.5	1.1	0.86	3.19	0.75	0.06	25.0	16.1	1.8
0.5	1	0.73	3.28	0.68	0.05	25.0	12.5	1.6
0.5	1.3	1	4.16	0.12	0.00	25.0	3.0	2.7
0.5	1.3	1	4.96	0.00	0.00	25.0	0.0	3.2
0.5	1.2	0.93	4.96	0.00	0.00	25.0	0.0	3.0
0.5	1.2	0.93	4.37	0.06	0.00	25.0	1.3	2.6
0.5	1.2	0.93	3.72	0.36	0.01	25.0	8.4	2.2
0.5	1.3	1	3.21	0.73	0.06	25.0	18.3	2.1
0.5	1.4	0.91	3.43	0.58	0.03	25.0	13.1	2.4
0.5	1.4	0.91	3.13	0.79	0.07	25.0	17.9	2.2
0.5	1.2	0.93	3.72	0.36	0.01	25.0	8.4	2.2
0.5	1.2	0.93	2.61	1.00	0.12	25.0	23.2	1.6
0.5	1	0.73	3.5	0.52	0.02	25.0	9.6	1.8
0.5	0.9	0.6	2.24	0.89	0.10	25.0	13.4	1.0
0.75	0.5	0.19	0.83	0.08	0.00	37.5	0.6	0.3
0.5	0	0	0	0.00	0.00	25.0	0.0	0.0
0	0.00	0	0.00	0	0	0.0	0.0	0.0
						475.0	179.6	32.9

1+50 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.75	0.00	0	0.00	0.00	0.00	37.5	0.0	0.0
1	1.2	0.93	0.7	0.05	0.05	50.0	2.4	0.8
0.5	1.2	0.93	0.97	0.11	0.11	25.0	2.6	0.6
0.5	1.4	0.91	2.05	0.77	0.71	25.0	17.6	1.4
0.5	1.3	1	2.92	0.90	0.90	25.0	22.6	1.9
0.5	1.3	1	3.65	0.41	0.41	25.0	10.3	2.4
0.5	1.3	1	4.75	0.00	0.00	25.0	0.0	3.1
0.5	1.2	0.93	3.98	0.21	0.20	25.0	4.9	2.4
0.5	1.2	0.93	3.28	0.68	0.64	25.0	15.9	2.0
0.5	1.1	0.86	2.92	0.90	0.78	25.0	19.4	1.6
0.5	1.1	0.86	2.92	0.90	0.78	25.0	19.4	1.6
0.5	1	0.73	4.28	0.08	0.06	25.0	1.5	2.1
0.5	1	0.73	4.26	0.09	0.06	25.0	1.6	2.1
0.5	0.9	0.6	3.65	0.41	0.25	25.0	6.2	1.6
0.5	0.8	0.475	3.13	0.79	0.37	25.0	9.4	1.3
0.5	0.7	0.35	2.8	0.94	0.33	25.0	8.2	1.0
0.5	0.7	0.35	2.05	0.77	0.27	25.0	6.8	0.7
0.5	0.6	0.27	2.39	0.94	0.25	25.0	6.3	0.7
0.5	0.7	0.35	2.34	0.92	0.32	25.0	8.1	0.8
0.75	0.8	0.48	1.67	0.51	0.24	37.5	9.0	1.0
1.25	0.5	0.19	1.47	0.36	0.07	62.5	4.3	0.9
0.75	0	0	0	0.00	0.00	37.5	0.0	0.0
0	0.00	0	0.00	0	0	0.0	0.0	0.0
						650.0	176.5	30.1

2+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.70	0.35	0.88	0.09	0.03	12.5	0.4	0.2
0.5	0.7	0.35	1.76	0.57	0.20	25.0	5.0	0.6
0.5	0.6	0.27	1.44	0.34	0.09	25.0	2.3	0.4
0.5	0.5	0.19	1.65	0.49	0.09	25.0	2.3	0.4
0.5	0.45	0.165	1.44	0.34	0.06	25.0	1.4	0.3
0.5	0.4	0.14	1.47	0.36	0.05	25.0	1.3	0.3
0.5	0.4	0.14	1.44	0.34	0.05	25.0	1.2	0.3
0.5	0.5	0.19	2.12	0.82	0.16	25.0	3.9	0.5
0.5	0.5	0.19	3.06	0.84	0.16	25.0	4.0	0.8
0.5	0.5	0.19	1.41	0.32	0.06	25.0	1.5	0.4
0.5	0.6	0.27	2.74	0.96	0.26	25.0	6.5	0.8
0.5	0.6	0.27	2.39	0.94	0.25	25.0	6.3	0.7
0.5	0.8	0.475	3.8	0.30	0.14	25.0	3.6	1.5
0.5	0.9	0.6	3.28	0.68	0.41	25.0	10.3	1.5
0.5	1	0.73	3.21	0.73	0.54	25.0	13.4	1.6
0.5	0.9	0.6	3.21	0.73	0.44	25.0	11.0	1.4
0.5	1	0.73	3.5	0.52	0.38	25.0	9.6	1.8
0.5	1	0.73	3.98	0.21	0.15	25.0	3.8	2.0
0.5	1	0.73	4.75	0.00	0.00	25.0	0.0	2.4
0.5	1	0.73	4.37	0.06	0.04	25.0	1.0	2.2
0.5	1.1	0.86	3.5	0.52	0.45	25.0	11.3	1.9
0.5	1.1	0.86	2.68	0.98	0.84	25.0	21.0	1.5
0.5	1.1	0.86	3.13	0.79	0.68	25.0	17.0	1.7
0.5	1	0.73	3.65	0.41	0.30	25.0	7.5	1.8
1	0.7	0.35	1.65	0.49	0.17	50.0	8.6	1.2
0.75	0	0	0	0.00	0.00	37.5	0.0	0.0
0	0.00	0	0.00	0	0.00	0.0	0.0	0.0
						675.0	154.1	28.2

2+50 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	1.30	1	0.87	0.09	0.09	12.5	1.1	0.3
0.5	1.4	0.91	1.73	0.55	0.50	25.0	12.5	1.2
0.5	1.4	0.91	2	0.74	0.67	25.0	16.8	1.4
0.5	1.3	1	2.55	0.98	0.98	25.0	24.6	1.7
0.5	1.2	0.93	3.06	0.84	0.78	25.0	19.5	1.8
0.5	1.2	0.93	3.21	0.73	0.68	25.0	17.0	1.9
0.5	1.1	0.86	3.72	0.36	0.31	25.0	7.7	2.0
0.5	1.2	0.93	3.5	0.52	0.49	25.0	12.2	2.1
0.5	1.1	0.86	3.57	0.47	0.41	25.0	10.2	2.0
0.5	1.1	0.86	3.98	0.21	0.18	25.0	4.5	2.2
0.5	1	0.73	4.07	0.16	0.12	25.0	3.0	2.0
0.5	1	0.73	3.98	0.21	0.15	25.0	3.8	2.0
0.5	0.9	0.6	3.89	0.25	0.15	25.0	3.8	1.8
0.5	0.9	0.6	3.8	0.30	0.18	25.0	4.5	1.7
0.5	0.9	0.6	4.07	0.16	0.10	25.0	2.5	1.8
0.5	0.9	0.6	3.98	0.21	0.13	25.0	3.2	1.8
0.5	0.7	0.35	3.06	0.84	0.29	25.0	7.3	1.1
0.25	0.6	0.27	1.53	0.40	0.11	12.5	1.4	0.2
0	0.00	0	0.00	0	0.00	0.0	0.0	0.0
						425.0	155.7	29.0

3+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.75	0.00	0	0.00	0.00	0.00	37.5	0.0	0.0
1	0.6	0.27	3.06	0.84	0.23	50.0	11.3	1.8
0.5	0.8	0.475	3.28	0.68	0.32	25.0	8.1	1.3
0.5	1	0.73	3.37	0.62	0.45	25.0	11.3	1.7
0.5	1.1	0.86	3.28	0.68	0.59	25.0	14.7	1.8
0.5	1.2	0.93	3.21	0.73	0.68	25.0	17.0	1.9
0.5	1.2	0.93	3.43	0.58	0.54	25.0	13.4	2.1
0.5	1.2	0.93	3.65	0.41	0.38	25.0	9.6	2.2
0.5	1.3	1	3.89	0.25	0.25	25.0	6.4	2.5
0.5	1.2	0.93	3.28	0.68	0.64	25.0	15.9	2.0
0.5	1.2	0.93	3.89	0.25	0.24	25.0	5.9	2.3
0.5	1.1	0.86	3.72	0.36	0.31	25.0	7.7	2.0
0.5	1.1	0.86	3.8	0.30	0.26	25.0	6.4	2.1
0.5	1.1	0.86	3.8	0.30	0.26	25.0	6.4	2.1
0.5	1.1	0.86	3.5	0.52	0.45	25.0	11.3	1.9
0.5	1	0.73	2.44	0.95	0.69	25.0	17.4	1.2
4.25	0.7	0.35	1.06	0.15	0.05	212.5	11.0	3.2
4	0	0	0	0.00	0.00	200.0	0.0	0.0
0	0.00	0	0.00	0	0.00	0.0	0.0	0.0
						850.0	174.1	32.2

3+50 RL= 55

W	D	SI	V	SI	SI*SI	T A	WT A	Q
2	0.00	0	0.00	0.00	0.00	110.0	0.0	0.0
2.5	0.8	0.475	0.5	0.02	0.01	137.5	1.5	1.0
1	0.9	0.6	0.93	0.10	0.06	55.0	3.4	0.8
1	1.1	0.86	1.11	0.17	0.15	55.0	8.1	1.2
0.75	1.3	1	1.65	0.49	0.49	41.3	20.3	1.6
0.5	1.5	0.82	2.05	0.77	0.64	27.5	17.5	1.5
0.5	1.6	0.605	2.39	0.94	0.57	27.5	15.6	1.9
0.5	1.7	0.39	2.44	0.95	0.37	27.5	10.2	2.1
0.5	1.7	0.39	2.61	1.00	0.39	27.5	10.7	2.2
0.5	1.7	0.39	2.5	0.97	0.38	27.5	10.4	2.1
0.5	1.9	0.07	2.29	0.91	0.06	27.5	1.7	2.2
0.5	1.8	0.23	2.44	0.95	0.22	27.5	6.0	2.2
0.5	1.7	0.39	3.5	0.52	0.20	27.5	5.6	3.0
0.75	1.8	0.23	2.1	0.81	0.19	41.3	7.7	2.8
0.5	1.1	0.86	1.05	0.14	0.12	27.5	3.4	0.6
0	0.00	0	0.00	0	0.00	0.0	0.0	0.0
						687.5	122.2	25.3

4+10 RL= 45

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1	0.00	0	0.00	0.00	0.00	45.0	0.0	0.0
1.5	1.4	0.91	0.93	0.10	0.09	67.5	6.4	2.0
1	1.4	0.91	1.06	0.15	0.14	45.0	6.1	1.5
1	1.5	0.82	1.06	0.15	0.12	45.0	5.5	1.6
1	1.5	0.82	1.06	0.15	0.12	45.0	5.5	1.6
1	1.6	0.605	1.21	0.22	0.13	45.0	6.0	1.9
0.75	1.8	0.23	1.51	0.39	0.09	33.8	3.0	2.0
0.5	1.9	0.07	1.62	0.47	0.03	22.5	0.7	1.5
0.5	2	0.035	1.84	0.63	0.02	22.5	0.5	1.8
0.5	2	0.035	2.1	0.81	0.03	22.5	0.6	2.1
0.5	2	0.035	2.2	0.88	0.03	22.5	0.7	2.2
0.5	2.2	0	2.1	0.81	0.00	22.5	0.0	2.3
0.5	2.3	0	2.05	0.77	0.00	22.5	0.0	2.4
0.5	2.3	0	1.65	0.49	0.00	22.5	0.0	1.9
0.5	2.1	0	1.51	0.39	0.00	22.5	0.0	1.6
0.5	1.9	0.07	1.23	0.23	0.02	22.5	0.4	1.2
0.75	1.8	0.23	1.28	0.25	0.06	33.8	2.0	1.7
1.25	1.5	0.82	0.64	0.04	0.03	56.3	1.8	1.2
0.75	0	0	0	0.00	0.00	33.8	0.0	0.0
0	0.00	0	0.00	0	0.00	0.0	0.0	0.0
						652.5	39.1	30.5

4+40 RL= 44

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1.25	0.00	0	0.00	0.00	0.00	55.0	0.0	0.0
1.75	1.4	0.91	0.45	0.02	0.02	77.0	1.3	1.1
1	1.5	0.82	1.17	0.20	0.16	44.0	7.2	1.8
1	1.6	0.605	1.44	0.34	0.21	44.0	9.0	2.3
1	1.5	0.82	1.62	0.47	0.38	44.0	16.9	2.4
1	1.5	0.82	1.51	0.39	0.32	44.0	14.1	2.3
1	1.4	0.91	1.92	0.68	0.62	44.0	27.4	2.7
1	1.4	0.91	2.1	0.81	0.74	44.0	32.4	2.9
1	1.2	0.93	2.15	0.84	0.79	44.0	34.6	2.6
1	1.1	0.86	2.2	0.88	0.76	44.0	33.3	2.4
1	1	0.73	2.2	0.88	0.64	44.0	28.3	2.2
1	0.9	0.6	1.92	0.68	0.41	44.0	18.1	1.7
1	1	0.73	1.62	0.47	0.34	44.0	15.1	1.6
1	0.9	0.6	1.54	0.41	0.25	44.0	10.9	1.4
1	0.9	0.6	1.25	0.24	0.14	44.0	6.3	1.1
1	0.8	0.475	1.11	0.17	0.08	44.0	3.6	0.9
1	0.8	0.475	0.95	0.11	0.05	44.0	2.3	0.8
3.5	0.6	0.27	0.76	0.07	0.02	154.0	2.7	1.6
3	0	0	0	0.00	0.00	132.0	0.0	0.0
0	0.00	0	0.00	0	0	0.0	0.0	0.0
						1078.0	263.5	31.8
						6865.0	1567.2	301.0
							0.23	30.10

6-27-90

0+07 RL= 29

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1.5	0.00	0	0.00	0.00	0.00	43.5	0.0	0.0
2	0.50	0.19	0.70	0.05	0.01	58.0	0.6	0.7
0.5	0.50	0.19	0.84	0.08	0.02	14.5	0.2	0.2
1.75	0.50	0.19	0.83	0.08	0.02	50.8	0.8	0.7
1.75	0.70	0.35	0.60	0.03	0.01	50.8	0.5	0.7
0.5	0.80	0.475	0.81	0.08	0.04	14.5	0.5	0.3
0.5	0.90	0.6	0.95	0.11	0.07	14.5	0.9	0.4
0.5	1.00	0.73	0.99	0.12	0.09	14.5	1.2	0.5
0.5	1.00	0.73	1.17	0.20	0.15	14.5	2.1	0.6
0.5	1.10	0.86	1.51	0.39	0.34	14.5	4.9	0.8
0.5	1.20	0.93	1.51	0.39	0.36	14.5	5.3	0.9
0.5	1.30	1	1.62	0.47	0.47	14.5	6.8	1.1
0.5	1.40	0.91	1.76	0.57	0.52	14.5	7.5	1.2
0.5	1.50	0.82	2.20	0.88	0.72	14.5	10.5	1.7
0.5	1.70	0.39	2.44	0.95	0.37	14.5	5.4	2.1
0.5	1.90	0.07	2.68	0.98	0.07	14.5	1.0	2.5
0.5	2.10	0	2.68	0.98	0.00	14.5	0.0	2.8
0.5	2.3	0	2.61	1.00	0.00	14.5	0.0	3.0
0.5	2.5	0	2.29	0.91	0.00	14.5	0.0	2.9
0.5	2.7	0	2.55	0.98	0.00	14.5	0.0	3.4
0.25	2.80	0	2.04	0.77	0.00	7.3	0.0	1.4
						442.3	48.3	28.0

0+50 RL= 46

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1	0.00	0	0.00	0.00	0.00	46.0	0.0	0.0
1.5	0.80	0.475	0.28	0.01	0.00	69.0	0.2	0.3
0.75	1.40	0.91	0.65	0.04	0.04	34.5	1.3	0.7
0.5	1.60	0.605	1.11	0.17	0.10	23.0	2.4	0.9
0.5	1.80	0.23	1.80	0.60	0.14	23.0	3.2	1.6
0.5	2.00	0.035	2.05	0.77	0.03	23.0	0.6	2.1
0.5	1.90	0.07	1.76	0.57	0.04	23.0	0.9	1.7
0.5	1.70	0.39	0.79	0.07	0.03	23.0	0.7	0.7
0.5	1.70	0.39	1.21	0.22	0.09	23.0	2.0	1.0
0.5	1.60	0.605	2.20	0.88	0.53	23.0	12.2	1.8
0.5	1.50	0.82	3.13	0.79	0.65	23.0	14.9	2.3
0.5	1.50	0.82	2.74	0.96	0.79	23.0	18.1	2.1
0.5	1.40	0.91	2.20	0.88	0.80	23.0	18.4	1.5
0.5	1.30	1	1.84	0.63	0.63	23.0	14.4	1.2
0.5	1.20	0.93	1.65	0.49	0.46	23.0	10.5	1.0
0.5	1.20	0.93	1.76	0.57	0.53	23.0	12.2	1.1
0.5	1.20	0.93	2.00	0.74	0.69	23.0	15.8	1.2
2	1.2	0.93	0.8	0.08	0.07	92.0	6.4	1.9
3.25	1.1	0.86	2.29	0.91	0.78	149.5	116.6	8.2
3	0.8	0.475	3.5	0.52	0.00	138.0	34.4	8.4
1.5	0	0	0	0.00	0.00	69.0	0.0	0.0
						920.0	285.3	39.6

15-Oct-90

15-Oct-90

1+00	RL=	50						
W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.70	0.35	0.81	0.08	0.03	12.5	0.3	0.1
0.5	0.90	0.6	1.62	0.47	0.28	25.0	7.0	0.7
0.5	1.30	1	3.24	0.71	0.71	25.0	17.8	2.1
0.5	1.40	0.91	4.16	0.12	0.11	25.0	2.7	2.9
0.5	1.40	0.91	4.37	0.06	0.05	25.0	1.3	3.1
0.5	1.30	1	4.37	0.06	0.06	25.0	1.4	2.8
0.5	1.20	0.93	3.98	0.21	0.20	25.0	4.9	2.4
0.5	1.10	0.86	3.28	0.68	0.59	25.0	14.7	1.8
0.5	1.10	0.86	2.92	0.90	0.78	25.0	19.4	1.6
0.5	1.10	0.86	3.28	0.68	0.59	25.0	14.7	1.8
0.5	1.10	0.86	2.55	0.98	0.85	25.0	21.2	1.4
0.5	1.20	0.93	2.39	0.94	0.87	25.0	21.8	1.4
0.5	1.20	0.93	2.10	0.81	0.75	25.0	18.8	1.3
0.5	1.10	0.86	2.86	0.92	0.79	25.0	19.8	1.6
0.5	1.10	0.86	2.74	0.96	0.82	25.0	20.6	1.5
0.5	1.00	0.73	3.57	0.47	0.34	25.0	8.6	1.8
0.75	1.00	0.73	3.37	0.62	0.45	37.5	17.0	2.5
0.5	0	0	0	0.00	0.00	25.0	0.0	0.0
						450.0	212.2	30.9

1+50	RL=	50						
W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.75	0.00	0	0.00	0.00	0.00	37.5	0.0	0.0
1	1.00	0.73	0.86	0.09	0.06	50.0	3.2	0.9
0.5	1.00	0.73	1.92	0.68	0.50	25.0	12.5	1.0
0.5	1.10	0.86	2.34	0.92	0.79	25.0	19.8	1.3
0.5	1.10	0.86	2.80	0.94	0.81	25.0	20.2	1.5
0.5	1.30	1	3.24	0.71	0.71	25.0	17.8	2.1
0.5	1.20	0.93	3.28	0.68	0.64	25.0	15.9	2.0
0.5	1.10	0.86	1.65	0.49	0.42	25.0	10.6	0.9
0.5	1.20	0.93	3.80	0.30	0.28	25.0	7.0	2.3
0.5	1.10	0.86	4.16	0.12	0.10	25.0	2.6	2.3
0.5	1.00	0.73	3.72	0.36	0.26	25.0	6.6	1.9
0.5	0.90	0.6	3.80	0.30	0.18	25.0	4.5	1.7
0.5	0.90	0.6	3.65	0.41	0.25	25.0	6.2	1.6
0.5	0.80	0.475	3.72	0.36	0.17	25.0	4.3	1.5
0.5	0.80	0.475	3.13	0.79	0.37	25.0	9.4	1.3
0.5	0.70	0.35	2.69	0.97	0.34	25.0	8.5	0.9
0.5	0.60	0.27	2.24	0.89	0.24	25.0	6.0	0.7
0.5	0.5	0.19	2.05	0.77	0.15	25.0	3.7	0.5
0.5	0.5	0.19	1.73	0.55	0.10	25.0	2.6	0.4
1.25	0.45	0.165	1.7	0.53	0.09	62.5	5.4	1.0
1	0	0	0	0.00	0.00	50.0	0.0	0.0
						625.0	166.7	25.7

2+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.50	0.19	0.83	0.08	0.02	12.5	0.2	0.1
0.5	0.50	0.19	1.38	0.30	0.06	25.0	1.4	0.3
0.5	0.50	0.19	1.88	0.66	0.12	25.0	3.1	0.5
0.5	0.40	0.14	1.51	0.39	0.05	25.0	1.4	0.3
0.5	0.40	0.14	1.54	0.41	0.06	25.0	1.4	0.3
0.5	0.40	0.14	2.29	0.91	0.13	25.0	3.2	0.5
0.75	0.40	0.14	2.44	0.95	0.13	37.5	5.0	0.7
0.75	0.30	0.09	1.44	0.34	0.03	37.5	1.1	0.3
0.5	0.50	0.19	2.50	0.97	0.18	25.0	4.6	0.6
0.5	0.60	0.27	1.96	0.71	0.19	25.0	4.8	0.6
0.5	0.80	0.475	3.50	0.52	0.25	25.0	6.2	1.4
0.5	0.60	0.27	3.98	0.21	0.06	25.0	1.4	1.2
0.5	0.70	0.35	3.50	0.52	0.18	25.0	4.6	1.2
0.5	0.80	0.475	3.72	0.36	0.17	25.0	4.3	1.5
0.5	0.90	0.6	3.43	0.58	0.35	25.0	8.7	1.5
0.5	0.90	0.6	3.06	0.84	0.50	25.0	12.6	1.4
0.5	0.9	0.6	3.57	0.47	0.28	25.0	7.1	1.6
0.5	1.1	0.86	4.07	0.16	0.14	25.0	3.5	2.2
0.5	1.00	0.73	3.98	0.21	0.15	25.0	3.8	2.0
0.5	1.1	0.86	2.5	0.97	0.83	25.0	20.9	1.4
0.5	1.1	0.86	2.68	0.98	0.84	25.0	21.0	1.5
0.5	1	0.73	3.21	0.73	0.54	25.0	13.4	1.6
0.5	0.9	0.6	2.44	0.95	0.57	25.0	14.3	1.1
0.5	0.8	0.475	1.28	0.25	0.12	25.0	3.0	0.5
0.75	0.6	0.27	1.03	0.13	0.04	37.5	1.4	0.5
0.5	0		0	0.00	0.00	25.0	0.0	0.0
						675.0	152.4	24.8

2+50 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.5	1.40	0.91	1.03	0.13	0.12	25.0	3.1	0.7
0.75	1.30	1	2.05	0.77	0.77	37.5	29.1	2.0
0.5	1.20	0.93	2.34	0.92	0.86	25.0	21.4	1.4
0.5	1.20	0.93	3.13	0.79	0.73	25.0	18.3	1.9
0.5	1.20	0.93	2.74	0.96	0.89	25.0	22.3	1.6
0.5	1.10	0.86	3.06	0.84	0.72	25.0	18.0	1.7
0.5	1.00	0.73	3.21	0.73	0.54	25.0	13.4	1.6
0.5	0.90	0.6	3.98	0.21	0.13	25.0	3.2	1.8
0.5	1.00	0.73	3.80	0.30	0.22	25.0	5.5	1.9
0.5	1.00	0.73	4.16	0.12	0.09	25.0	2.2	2.1
0.5	1.00	0.73	3.98	0.21	0.15	25.0	3.8	2.0
0.5	0.90	0.6	3.89	0.25	0.15	25.0	3.8	1.8
0.5	1	0.73	3.8	0.30	0.22	25.0	5.5	1.9
0.5	0.90	0.6	4.16	0.12	0.07	25.0	1.8	1.9
0.5	0.8	0.475	4.46	0.03	0.02	25.0	0.4	1.8
0.5	0.6	0.27	2.8	0.94	0.25	25.0	6.3	0.8
0.25	0.6	0.27	1.4	0.31	0.08	12.5	1.0	0.2
						425.0	159.1	27.1

3+00 RL= 50

W	D	SI	V	SI	SI*SI	T A	WT A	Q
0.25	0.00	0	0.00	0.00	0.00	12.5	0.0	0.0
0.5	0.75	0.4125	2.80	0.94	0.39	25.0	9.7	1.1
0.5	0.80	0.475	2.68	0.98	0.46	25.0	11.6	1.1
0.5	1.00	0.73	2.39	0.94	0.68	25.0	17.1	1.2
0.5	1.00	0.73	2.92	0.90	0.66	25.0	16.5	1.5
0.5	1.10	0.86	3.28	0.68	0.59	25.0	14.7	1.8
0.5	1.10	0.86	3.28	0.68	0.59	25.0	14.7	1.8
0.5	1.20	0.93	3.72	0.36	0.33	25.0	8.4	2.2
0.5	1.20	0.93	3.89	0.25	0.24	25.0	5.9	2.3
0.5	1.20	0.93	3.72	0.36	0.33	25.0	8.4	2.2
0.5	1.2	0.93	3.8	0.30	0.28	25.0	7.0	2.3
0.5	1.20	0.93	3.57	0.47	0.44	25.0	11.0	2.1
0.5	1	0.73	3.8	0.30	0.22	25.0	5.5	1.9
0.5	1	0.73	3.72	0.36	0.26	25.0	6.6	1.9
0.5	0.9	0.6	2.86	0.92	0.55	25.0	13.8	1.3
1	0.85	0.5375	1.65	0.49	0.26	50.0	13.2	1.4
0.75	0	0	0	0.00	0.00	37.5	0.0	0.0
						450.0	164.0	26.1

3+50 RL= 55

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1	0.80	0.475	0.22	0.00	0.00	55.0	0.0	0.2
1.75	0.75	0.4125	0.43	0.02	0.01	96.3	0.7	0.6
1	1.20	0.93	1.01	0.12	0.12	55.0	6.4	1.2
0.5	1.30	1	1.44	0.34	0.34	27.5	9.3	0.9
0.5	1.40	0.91	1.73	0.55	0.50	27.5	13.7	1.2
0.5	1.50	0.82	2.05	0.77	0.64	27.5	17.5	1.5
0.5	1.70	0.39	2.20	0.88	0.34	27.5	9.4	1.9
0.5	1.80	0.23	2.29	0.91	0.21	27.5	5.7	2.1
0.5	1.80	0.23	2.44	0.95	0.22	27.5	6.0	2.2
0.5	1.90	0.07	1.65	0.49	0.03	27.5	0.9	1.6
0.5	1.9	0.07	2.2	0.88	0.06	27.5	1.7	2.1
0.5	1.80	0.23	1.44	0.34	0.08	27.5	2.1	1.3
0.5	1.8	0.23	2.1	0.81	0.19	27.5	5.1	1.9
0.5	1.7	0.39	2.05	0.77	0.30	27.5	8.3	1.7
0.75	1	0.73	2.68	0.98	0.71	41.3	29.4	2.0
0.5	0.7	0.35	1.34	0.28	0.10	27.5	2.7	0.5
						577.5	119.2	22.8

4+10 RL= 45

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1	0.00	0	0.00	0.00	0.00	45.0	0.0	0.0
1.5	1.50	0.82	0.67	0.05	0.04	67.5	2.5	1.5
1	1.60	0.605	0.99	0.12	0.07	45.0	3.2	1.6
1	1.70	0.39	1.01	0.12	0.05	45.0	2.2	1.7
1	1.70	0.39	0.91	0.10	0.04	45.0	1.8	1.5
1	1.80	0.23	1.08	0.16	0.04	45.0	1.6	1.9
1	2.00	0.035	1.11	0.17	0.01	45.0	0.3	2.2
1	2.20	0	1.62	0.47	0.00	45.0	0.0	3.6
1	2.20	0	1.92	0.68	0.00	45.0	0.0	4.2
1	2.20	0	1.65	0.49	0.00	45.0	0.0	3.6
1	2	0.035	1.58	0.44	0.02	45.0	0.7	3.2
1	1.80	0.23	0.99	0.12	0.03	45.0	1.2	1.8
1.5	1.5	0.82	0.4	0.02	0.01	67.5	0.8	0.9
1	0	0	0	0.00	0.00	45.0	0.0	0.0
						675.0	14.3	27.8

4+40 RL= 44

W	D	SI	V	SI	SI*SI	T A	WT A	Q
1	0.00	0	0.00	0.00	0.00	44.0	0.0	0.0
1.5	1.40	0.91	0.48	0.02	0.02	66.0	1.3	1.0
1	1.50	0.82	1.08	0.16	0.13	44.0	5.7	1.6
1	1.60	0.605	1.96	0.71	0.43	44.0	19.0	3.1
1	1.50	0.82	1.61	0.46	0.38	44.0	16.7	2.4
1	1.40	0.91	1.62	0.47	0.43	44.0	18.8	2.3
1	1.40	0.91	1.88	0.66	0.60	44.0	26.3	2.6
1	1.40	0.91	1.84	0.63	0.57	44.0	25.1	2.6
1	1.20	0.93	2.10	0.81	0.75	44.0	33.1	2.5
1	1.00	0.73	2.20	0.88	0.64	44.0	28.3	2.2
1	1	0.73	2.05	0.77	0.57	44.0	24.9	2.1
1	1.10	0.86	1.70	0.53	0.45	44.0	20.0	1.9
1	1	0.73	1.54	0.41	0.30	44.0	13.2	1.5
1	0.9	0.6	1.41	0.32	0.19	44.0	8.4	1.3
1	0.8	0.475	1.23	0.23	0.11	44.0	4.8	1.0
1	0.8	0.475	1.11	0.17	0.08	44.0	3.6	0.9
1	0.7	0.35	1.06	0.15	0.05	44.0	2.3	0.7
3.5	0.6	0.27	0.77	0.07	0.02	154.0	2.8	1.6
3	0	0	0	0.00	0.00	132.0	0.0	0.0
						1056.0	254.2	31.3
						6295.8	1575.7	284.1
							0.25	28.4

APPENDIX K

APPENDIX K-1

ELEVATION-AREA-CAPACITY TABLE

Middle Creek Elevation - Area - Capacity Data

ELEV	AREA	CAPACITY
6625.0	1.7	.0
6630.0	7.7	21.5
6640.0	33.1	210.5
6650.0	61.3	675.3
6660.0	75.1	1356.2
6670.0	96.4	2211.4
6680.0	118.0	3281.6
6690.0	140.0	4570.1
6700.0	155.0	6044.4
6710.0	200.0	7814.7
6720.0	250.0	10060.0
6730.0	302.0	12815.9
6740.0	332.0	15984.7
6750.0	381.0	19546.9

NOTES:

Area in Acres
Capacity in Acre-feet
Principal spillway crest elevation = 6721.0 feet
Auxiliary spillway crest elevation = 6723.0 feet
Dam crest elevation = 6730.0

Middle Creek Elevation - Area - Capacity Data Take of 126 AF for live storage

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
6625.0	0	0	0	1	1	1	1	1	2	2
	2	2	2	2	2	2	2	2	2	2
6626.0	2	2	3	3	3	3	4	4	4	5
	3	3	3	3	3	3	3	3	3	3
6627.0	5	5	6	6	7	7	7	8	8	9
	4	4	4	4	4	4	4	4	4	5
6628.0	9	10	10	11	11	12	12	13	13	14
	5	5	5	5	5	5	6	6	6	6
6629.0	15	15	16	17	17	18	19	19	20	21
	6	6	6	7	7	7	7	7	7	8
6630.0	21	22	23	24	25	26	26	27	28	29
	8	8	8	8	8	9	9	9	9	9
6631.0	30	31	32	33	34	35	36	37	38	39
	9	10	10	10	10	10	11	11	11	11
6632.0	40	42	43	44	45	46	48	49	50	51
	11	12	12	12	12	12	13	13	13	13
6633.0	53	54	55	57	58	60	61	63	64	66
	13	14	14	14	14	15	15	15	15	15
6634.0	67	69	70	72	74	75	77	79	81	82
	16	16	16	16	17	17	17	17	18	18
6635.0	84	86	88	90	92	94	96	98	100	102
	18	18	19	19	19	19	20	20	20	21
6636.0	104	106	108	110	112	114	117	119	121	124
	21	21	21	22	22	22	22	23	23	23
6637.0	126	128	131	133	136	138	141	143	146	148
	24	24	24	24	25	25	25	26	26	26
6638.0	151	154	156	159	162	165	167	170	173	176
	27	27	27	28	28	28	28	29	29	29
6639.0	179	182	185	188	191	194	198	201	204	207
	30	30	30	31	31	31	32	32	32	33

Area in acres
Capacity in acre-feet

Middle Creek Elevation - Area - Capacity Data

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
6640.0	211	214	217	221	224	227	231	234	238	241
	33	33	34	34	34	34	35	35	35	35
6641.0	245	248	252	256	259	263	267	270	274	278
	36	36	36	36	37	37	37	37	38	38
6642.0	282	285	289	293	297	301	305	309	313	317
	38	38	39	39	39	39	40	40	40	40
6643.0	321	325	329	333	337	342	346	350	354	359
	41	41	41	41	42	42	42	43	43	43
6644.0	363	367	372	376	380	385	389	394	398	403
	43	44	44	44	44	45	45	45	46	46
6645.0	408	412	417	422	426	431	436	441	445	450
	46	46	47	47	47	48	48	48	48	49
6646.0	455	460	465	470	475	480	485	490	495	500
	49	49	50	50	50	50	51	51	51	52
6647.0	506	511	516	521	527	532	537	543	548	554
	52	52	53	53	53	53	54	54	54	55
6648.0	559	565	570	576	581	587	593	598	604	610
	55	55	56	56	56	57	57	57	57	58
6649.0	616	621	627	633	639	645	651	657	663	669
	58	58	59	59	59	60	60	60	61	61
6650.0	675	681	688	694	700	706	712	719	725	731
	61	61	62	62	62	62	62	62	62	62
6651.0	737	744	750	756	762	769	775	781	788	794
	63	63	63	63	63	63	63	64	64	64
6652.0	801	807	813	820	826	833	839	846	852	859
	64	64	64	64	64	65	65	65	65	65
6653.0	865	872	878	885	891	898	905	911	918	924
	65	65	66	66	66	66	66	66	66	67
6654.0	931	938	945	951	958	965	971	978	985	992
	67	67	67	67	67	67	67	68	68	68

Area in acres
Capacity in acre-feet

Middle Creek Elevation - Area - Capacity Data

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
6655.0	998	1005	1012	1019	1026	1033	1040	1046	1053	1060
	68	68	68	68	69	69	69	69	69	69
6656.0	1067	1074	1081	1088	1095	1102	1109	1116	1123	1130
	69	70	70	70	70	70	70	70	71	71
6657.0	1137	1144	1152	1159	1166	1173	1180	1187	1194	1202
	71	71	71	71	71	72	72	72	72	72
6658.0	1209	1216	1223	1231	1238	1245	1252	1260	1267	1274
	72	72	73	73	73	73	73	73	73	74
6659.0	1282	1289	1297	1304	1311	1319	1326	1334	1341	1349
	74	74	74	74	74	74	75	75	75	75
6660.0	1356	1364	1371	1379	1386	1394	1402	1409	1417	1425
	75	75	76	76	76	76	76	77	77	77
6661.0	1432	1440	1448	1455	1463	1471	1479	1487	1495	1502
	77	77	78	78	78	78	78	79	79	79
6662.0	1510	1518	1526	1534	1542	1550	1558	1566	1574	1582
	79	79	80	80	80	80	80	81	81	81
6663.0	1591	1599	1607	1615	1623	1631	1640	1648	1656	1664
	81	81	82	82	82	82	82	83	83	83
6664.0	1673	1681	1690	1698	1706	1715	1723	1732	1740	1749
	83	84	84	84	84	84	85	85	85	85
6665.0	1757	1766	1774	1783	1792	1800	1809	1818	1826	1835
	85	86	86	86	86	86	87	87	87	87
6666.0	1844	1852	1861	1870	1879	1888	1897	1906	1914	1923
	88	88	88	88	88	89	89	89	89	90
6667.0	1932	1941	1950	1959	1968	1977	1987	1996	2005	2014
	90	90	90	90	91	91	91	91	91	92
6668.0	2023	2032	2042	2051	2060	2069	2079	2088	2097	2107
	92	92	92	93	93	93	93	93	94	94
6669.0	2116	2126	2135	2145	2154	2164	2173	2183	2192	2202
	94	94	95	95	95	95	95	96	96	96

Area in acres
Capacity in acre-feet

Middle Creek Elevation - Area - Capacity Data

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
6670.0	2211	2221	2231	2240	2250	2260	2270	2279	2289	2299
	96	97	97	97	97	97	98	98	98	98
6671.0	2309	2319	2329	2338	2348	2358	2368	2378	2388	2398
	98	99	99	99	99	100	100	100	100	100
6672.0	2408	2418	2429	2439	2449	2459	2469	2479	2489	2500
	101	101	101	101	101	102	102	102	102	102
6673.0	2510	2520	2531	2541	2551	2562	2572	2582	2593	2603
	103	103	103	103	103	104	104	104	104	105
6674.0	2614	2624	2635	2645	2656	2666	2677	2688	2698	2709
	105	105	105	105	106	106	106	106	106	107
6675.0	2720	2730	2741	2752	2762	2773	2784	2795	2806	2817
	107	107	107	108	108	108	108	108	109	109
6676.0	2828	2838	2849	2860	2871	2882	2893	2904	2916	2927
	109	109	110	110	110	110	110	111	111	111
6677.0	2938	2949	2960	2971	2982	2994	3005	3016	3027	3039
	111	112	112	112	112	112	113	113	113	113
6678.0	3050	3062	3073	3084	3096	3107	3119	3130	3142	3153
	114	114	114	114	114	115	115	115	115	116
6679.0	3165	3176	3188	3200	3211	3223	3235	3246	3258	3270
	116	116	116	116	117	117	117	117	118	118
6680.0	3282	3293	3305	3317	3329	3341	3353	3365	3377	3389
	118	118	118	119	119	119	119	119	120	120
6681.0	3401	3413	3425	3437	3449	3461	3473	3485	3497	3510
	120	120	121	121	121	121	121	122	122	122
6682.0	3522	3534	3546	3559	3571	3583	3596	3608	3620	3633
	122	122	123	123	123	123	124	124	124	124
6683.0	3645	3658	3670	3683	3695	3708	3720	3733	3745	3758
	124	125	125	125	125	125	126	126	126	126
6684.0	3771	3783	3796	3809	3821	3834	3847	3860	3873	3885
	127	127	127	127	127	128	128	128	128	129

Area in acres
Capacity in acre-feet

Middle Creek Elevation - Area - Capacity Data

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
6685.0	3898	3911	3924	3937	3950	3963	3976	3989	4002	4015
	129	129	129	129	130	130	130	130	131	131
6686.0	4028	4041	4054	4068	4081	4094	4107	4120	4134	4147
	131	131	131	132	132	132	132	133	133	133
6687.0	4160	4174	4187	4200	4214	4227	4241	4254	4268	4281
	133	133	134	134	134	134	135	135	135	135
6688.0	4295	4308	4322	4335	4349	4363	4376	4390	4404	4417
	135	136	136	136	136	137	137	137	137	137
6689.0	4431	4445	4459	4473	4486	4500	4514	4528	4542	4556
	138	138	138	138	139	139	139	139	140	140
6690.0	4570	4584	4598	4612	4626	4640	4654	4668	4683	4697
	140	140	140	140	141	141	141	141	141	141
6691.0	4711	4725	4739	4753	4767	4782	4796	4810	4824	4839
	141	142	142	142	142	142	142	142	143	143
6692.0	4853	4867	4882	4896	4910	4925	4939	4953	4968	4982
	143	143	143	143	144	144	144	144	144	144
6693.0	4997	5011	5026	5040	5055	5069	5084	5098	5113	5127
	144	145	145	145	145	145	145	145	146	146
6694.0	5142	5156	5171	5186	5200	5215	5230	5244	5259	5274
	146	146	146	146	147	147	147	147	147	147
6695.0	5288	5303	5318	5333	5348	5362	5377	5392	5407	5422
	147	148	148	148	148	148	148	148	149	149
6696.0	5437	5452	5466	5481	5496	5511	5526	5541	5556	5571
	149	149	149	149	150	150	150	150	150	150
6697.0	5586	5601	5616	5631	5647	5662	5677	5692	5707	5722
	150	151	151	151	151	151	151	151	152	152
6698.0	5737	5753	5768	5783	5798	5814	5829	5844	5860	5875
	152	152	152	152	153	153	153	153	153	153
6699.0	5890	5906	5921	5936	5952	5967	5983	5998	6013	6029
	153	154	154	154	154	154	154	155	155	155

Area in acres
Capacity in acre-feet

Middle Creek Elevation - Area - Capacity Data

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
6700.0	6044 155	6060 155	6076 156	6091 156	6107 157	6122 157	6138 158	6154 158	6170 158	6186 159
6701.0	6202 159	6218 160	6234 160	6249 161	6266 161	6282 161	6298 162	6314 162	6330 163	6347 163
6702.0	6363 164	6379 164	6396 164	6412 165	6429 165	6445 166	6462 166	6479 167	6495 167	6512 167
6703.0	6529 168	6545 168	6562 169	6579 169	6596 170	6613 170	6630 171	6647 171	6664 171	6682 172
6704.0	6699 172	6716 173	6733 173	6751 174	6768 174	6785 175	6803 175	6820 175	6838 176	6856 176
6705.0	6873 177	6891 177	6909 178	6926 178	6944 179	6962 179	6980 179	6998 180	7016 180	7034 181
6706.0	7052 181	7071 182	7089 182	7107 183	7125 183	7144 184	7162 184	7180 185	7199 185	7217 185
6707.0	7236 186	7255 186	7273 187	7292 187	7311 188	7329 188	7348 189	7367 189	7386 190	7405 190
6708.0	7424 191	7443 191	7462 191	7481 192	7501 192	7520 193	7539 193	7559 194	7578 194	7598 195
6709.0	7617 195	7637 196	7656 196	7676 197	7695 197	7715 198	7735 198	7755 199	7775 199	7795 200
6710.0	7815 200	7835 200	7855 201	7875 201	7895 202	7915 202	7936 203	7956 203	7976 204	7997 204
6711.0	8017 205	8038 205	8058 206	8079 206	8099 207	8120 207	8141 208	8162 208	8182 209	8203 209
6712.0	8224 210	8245 210	8266 211	8287 211	8308 211	8330 212	8351 212	8372 213	8393 213	8415 214
6713.0	8436 214	8458 215	8479 215	8501 216	8522 216	8544 217	8566 217	8587 218	8609 218	8631 219
6714.0	8653 219	8675 220	8697 220	8719 221	8741 221	8763 222	8786 222	8808 223	8830 223	8852 224

Area in acres

Capacity in acre-feet

Middle Creek Elevation - Area - Capacity Data

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
6715.0	8875	8897	8920	8942	8965	8988	9010	9033	9056	9079
	224	225	225	226	226	227	227	228	228	229
6716.0	9102	9125	9148	9171	9194	9217	9240	9263	9287	9310
	229	230	230	231	231	232	232	233	233	234
6717.0	9334	9357	9381	9404	9428	9451	9475	9499	9523	9547
	234	235	235	236	236	237	237	238	239	239
6718.0	9570	9594	9619	9643	9667	9691	9715	9739	9764	9788
	240	240	241	241	242	242	243	243	244	244
6719.0	9813	9837	9862	9886	9911	9936	9960	9985	10010	10035
	245	245	246	246	247	247	248	248	249	249
6720.0	10060	10085	10110	10135	10160	10186	10211	10236	10262	10287
	250	250	251	251	252	252	253	253	254	254
6721.0	10312	10338	10364	10389	10415	10441	10466	10492	10518	10544
	255	255	256	256	257	257	258	258	259	260
6722.0	10570	10596	10622	10648	10674	10701	10727	10753	10780	10806
	260	261	261	262	262	263	263	264	264	265
6723.0	10833	10859	10886	10912	10939	10966	10993	11019	11046	11073
	265	266	266	267	267	268	268	269	269	270
6724.0	11100	11127	11154	11181	11209	11236	11263	11291	11318	11345
	270	271	271	272	272	273	273	274	274	275
6725.0	11373	11401	11428	11456	11484	11511	11539	11567	11595	11623
	275	276	276	277	277	278	279	279	280	280
6726.0	11651	11679	11707	11735	11764	11792	11820	11849	11877	11906
	281	281	282	282	283	283	284	284	285	285
6727.0	11934	11963	11992	12020	12049	12078	12107	12136	12165	12194
	286	286	287	287	288	289	289	290	290	291
6728.0	12223	12252	12281	12310	12340	12369	12398	12428	12457	12487
	291	292	292	293	293	294	294	295	295	296
6729.0	12517	12546	12576	12606	12636	12666	12696	12726	12756	12786
	297	297	298	298	299	299	300	300	301	301

Area in Acres
Capacity in acre-feet

Middle Creek Elevation - Area - Capacity Data

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           CAP     CAP     CAP     CAP     CAP     CAP     CAP     CAP     CAP     CAP
 ELEV     AREA    AREA    AREA    AREA    AREA    AREA    AREA    AREA    AREA    AREA
 FEET      .0      .1      .2      .3      .4      .5      .6      .7      .8      .9
########################################################################################

6730.0   12816   12846   12876   12907   12937   12967   12998   13028   13058   13089
           302     302     303     303     303     303     304     304     304     305

6731.0   13119   13150   13180   13211   13242   13272   13303   13334   13364   13395
           305     305     306     306     306     306     307     307     307     308

6732.0   13426   13457   13487   13518   13549   13580   13611   13642   13673   13704
           308     308     308     309     309     309     310     310     310     311

6733.0   13735   13766   13797   13828   13860   13891   13922   13954   13985   14016
           311     311     311     312     312     312     313     313     313     314

6734.0   14048   14079   14110   14142   14173   14205   14236   14268   14299   14331
           314     314     314     315     315     315     316     316     316     317
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6735.0   14363   14395   14426   14458   14490   14522   14553   14585   14617   14649
           317     317     317     318     318     318     319     319     319     320

6736.0   14681   14713   14745   14777   14809   14841   14874   14906   14938   14970
           320     320     320     321     321     321     322     322     322     323

6737.0   15002   15035   15067   15099   15132   15164   15197   15229   15262   15294
           323     323     323     324     324     324     325     325     325     326

6738.0   15327   15359   15392   15425   15457   15490   15523   15556   15588   15621
           326     326     326     327     327     327     328     328     328     329

6739.0   15654   15687   15720   15753   15786   15819   15852   15885   15918   15952
           329     329     330     330     330     330     331     331     331     332
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6740.0   15985   16018   16051   16084   16118   16151   16185   16218   16252   16285
           332     332     333     333     334     334     335     335     336     336

6741.0   16319   16353   16387   16420   16454   16488   16522   16556   16590   16624
           337     337     338     338     339     339     340     340     341     341

6742.0   16658   16692   16727   16761   16795   16830   16864   16899   16933   16968
           342     342     342     343     343     344     344     345     345     346

6743.0   17002   17037   17072   17106   17141   17176   17211   17246   17281   17316
           346     347     347     348     348     349     349     350     350     351

6744.0   17351   17386   17421   17456   17492   17527   17563   17598   17633   17669
           351     352     352     353     353     354     354     355     355     356
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Area in acres
Capacity in acre-feet

Middle Creek Elevation - Area - Capacity Data

ELEV FEET	CAP AREA .0	CAP AREA .1	CAP AREA .2	CAP AREA .3	CAP AREA .4	CAP AREA .5	CAP AREA .6	CAP AREA .7	CAP AREA .8	CAP AREA .9
6745.0	17705	17740	17776	17812	17847	17883	17919	17955	17991	18027
	356	357	357	358	358	359	359	360	360	361
6746.0	18063	18099	18135	18172	18208	18244	18281	18317	18353	18390
	361	361	362	362	363	363	364	364	365	365
6747.0	18427	18463	18500	18537	18573	18610	18647	18684	18721	18758
	366	366	367	367	368	368	369	369	370	370
6748.0	18795	18832	18869	18906	18944	18981	19019	19056	19093	19131
	371	371	372	372	373	373	374	374	375	375
6749.0	19168	19206	19244	19281	19319	19357	19395	19433	19471	19509
	376	376	377	377	378	378	379	379	380	380

Area in acres
Capacity in acre-feet

APPENDIX K-2
SPILLWAY RATING TABLE

APPENDIX K-2 - SPILLWAY RATING TABLE

Elevation (ft NGVD)	Principal Spillway (cfs)	Auxiliary Spillway (cfs)	Combined Spillway (cfs)
6721.0	0		0
.1	28		28
.2	59		59
.3	90		90
.4	125		125
.5	160		160
.6	200		200
.7	250		250
.8	305		305
.9	365		365
22.0	430		430
.1	495		495
.2	570		570
.3	640		640
.4	720		720
.5	800		800
.6	890		890
.7	975		975
.8	1070		1070
.9	1150		1150
23.0	1240	0	1240
.5	1710	300	2010
24.0	1950	1000	2950
.5	2110	2200	4310
25.0	2240	3500	5740
.5	2360	5100	7460
26.0	2480	7000	9480
.5	2590	9000	11590
27.0	2690	11200	13890
.5	2790	13600	16390
28.0	2890	16300	19190
.5	2980	19000	21980
29.0	3070	21800	24870
.5	3160	24900	28060
.9	3250	27300	30550

APPENDIX K-3
OUTLET WORKS RATING TABLE

RESERVOIR OUTFLOW RATING TABLE IN CUBIC FEET PER SECOND (CFS)

	STEM OPENING IN INCHES														
ELEV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6613	0	2	3	4	6	9	11	14	16	19	22	25	29	33	36
6614	1	2	4	6	9	13	16	20	23	27	31	36	41	46	51
6615	1	3	5	8	11	15	19	24	28	33	38	44	50	57	63
6616	1	4	6	9	13	18	22	28	33	38	44	51	58	66	72
6617	1	4	7	10	14	20	25	31	37	43	50	57	65	74	81
6618	1	4	7	11	16	22	28	34	40	47	54	62	72	81	89
6619	2	5	8	12	17	24	30	37	44	51	59	67	77	87	96
6620	2	5	9	13	18	25	32	40	47	55	63	72	83	93	103
6621	2	6	9	14	19	27	34	42	50	58	67	77	88	99	109
6622	2	6	10	15	20	28	36	44	52	61	70	81	92	104	115
6623	2	6	10	15	22	30	38	47	55	64	74	85	97	109	121
6624	2	7	11	16	22	31	39	49	57	67	77	89	101	114	126
6625	2	7	11	17	23	33	41	51	60	70	80	92	105	119	132
6626	2	7	12	17	24	34	42	53	62	73	84	96	109	123	137
6627	3	7	12	18	25	35	44	54	64	75	86	99	113	128	142
6628	3	8	12	19	26	36	45	56	66	78	89	102	117	132	146
6629	3	8	13	19	27	37	47	58	68	80	92	106	121	136	151
6630	3	8	13	20	28	38	48	60	70	83	95	109	124	140	155
6631	3	8	14	21	28	39	50	61	72	85	97	112	128	144	159
6632	3	9	14	21	29	40	51	63	74	87	100	114	131	147	164
6633	3	9	14	22	30	41	52	64	76	89	102	117	134	151	168
6634	3	9	15	22	31	42	53	66	78	91	105	120	137	155	172
6635	3	9	15	23	31	43	55	68	79	94	107	123	140	158	176
6636	3	9	15	23	32	44	56	69	81	96	110	125	143	161	179
6637	4	10	16	24	33	45	57	70	83	98	112	128	146	165	183
6638	4	10	16	24	33	46	58	72	84	100	114	131	149	168	187
6639	4	10	16	25	34	47	59	73	86	101	116	133	152	171	190
6640	4	10	17	25	35	48	60	75	88	103	118	136	155	174	194
6641	4	10	17	26	35	49	61	76	89	105	120	138	158	177	197
6642	4	11	17	26	36	49	63	77	91	107	123	140	160	181	201
6643	4	11	18	26	37	50	64	78	92	109	125	143	163	183	204
6644	4	11	18	27	37	51	65	80	94	111	127	145	166	186	207
6645	4	11	18	27	38	52	66	81	95	112	129	147	168	189	211
6646	4	11	18	28	38	53	67	82	96	114	130	149	171	192	214
6647	4	11	19	28	39	53	68	83	98	116	132	152	173	195	217
6648	4	12	19	29	39	54	69	85	99	117	134	154	176	198	220
6649	4	12	19	29	40	55	70	86	101	119	136	156	178	200	223
6650	5	12	19	29	41	56	70	87	102	121	138	158	181	203	226
6651	5	12	20	30	41	56	71	88	103	122	140	160	183	206	229
6652	5	12	20	30	42	57	72	89	105	124	142	162	185	208	232
6653	5	12	20	30	42	58	73	90	106	125	143	164	188	211	235
6654	5	13	20	31	43	59	74	91	107	127	145	166	190	214	238
6655	5	13	21	31	43	59	75	93	108	128	147	168	192	216	241
6656	5	13	21	32	44	60	76	94	110	130	149	170	194	219	244
6657	5	13	21	32	44	61	77	95	111	131	150	172	197	221	246
6658	5	13	21	32	45	61	78	96	112	133	152	174	199	223	249
6659	5	13	22	33	45	62	78	97	113	134	154	176	201	226	252
6560	5	13	22	33	46	63	79	98	115	136	155	178	203	228	255
6661	5	14	22	33	46	63	80	99	116	137	157	180	205	231	257
6662	5	14	22	34	47	64	81	100	117	139	158	181	207	233	260
6663	5	14	23	34	47	65	82	101	118	140	160	183	209	235	263
6664	5	14	23	34	48	65	83	102	119	141	162	185	211	238	265

RESERVOIR OUTFLOW RATING TABLE (continued) IN CUBIC FEET PER SECOND (CFS

	STEM OPENING IN INCHES													
ELEV	16	17	18	19	20	21	22	23	24	25	26	27	28	29
6613	40	45	50	54	58	65	70	75	81	85	89	91	93	95
6614	57	64	71	77	83	92	99	107	115	121	126	129	132	135
6615	70	78	87	94	102	113	121	131	141	148	155	159	162	165
6616	81	90	100	109	118	131	140	151	163	171	179	183	187	191
6617	91	101	112	122	132	146	157	169	182	192	200	205	209	213
6618	100	110	123	133	144	160	172	186	199	210	219	225	229	234
6619	108	119	133	144	156	173	186	201	215	227	237	243	248	253
6620	115	127	142	154	167	185	199	214	230	243	253	260	265	270
6621	122	135	151	163	177	196	211	228	244	258	268	276	281	287
6622	129	143	159	172	187	206	222	240	258	272	283	291	296	302
6623	135	150	166	181	196	216	233	252	270	285	297	305	311	317
6624	141	156	174	189	205	226	244	263	282	298	310	318	325	331
6625	147	163	181	197	214	235	254	274	294	310	323	332	338	345
6626	153	169	188	204	222	244	263	284	305	322	335	344	351	358
6627	158	175	194	211	230	252	273	294	316	333	347	356	364	371
6628	164	180	201	218	237	261	282	304	326	344	358	368	376	383
6629	169	186	207	225	245	269	290	313	336	355	369	379	387	395
6630	173	191	213	231	252	276	299	322	346	365	380	390	399	406
6631	178	197	219	238	259	284	307	331	355	375	391	401	410	417
6632	183	202	224	244	266	291	315	340	365	385	401	412	420	428
6633	187	207	230	250	272	298	323	348	374	395	411	422	431	439
6634	192	212	235	256	279	305	331	357	382	404	420	432	441	449
6635	196	216	241	262	285	312	338	365	391	413	430	441	451	459
6636	201	221	246	267	291	319	345	373	399	422	439	451	461	469
6637	205	225	251	273	297	325	352	380	408	431	448	460	470	479
6638	209	230	256	278	303	332	359	388	416	439	457	469	480	488
6639	213	234	261	284	309	338	366	395	424	448	466	478	489	498
6640	217	239	265	289	315	344	373	403	431	456	475	487	498	507
6641	221	243	270	294	320	350	380	410	439	464	483	496	507	516
6642	224	247	275	299	326	356	386	417	447	472	491	504	515	525
6643	228	251	279	304	331	362	393	424	454	480	499	513	524	534
6644	232	255	284	309	337	368	399	431	461	488	507	521	533	542
6645	235	259	288	314	342	374	405	437	468	495	515	529	541	551
6646	239	263	292	318	347	379	411	444	475	503	523	537	549	559
6647	242	267	297	323	352	385	417	450	482	510	531	545	557	567
6648	246	271	301	328	357	390	423	457	489	518	538	553	565	575
6649	249	274	305	332	362	395	429	463	496	525	546	560	573	583
6650	253	278	309	337	367	401	435	469	503	532	553	568	581	591
6651	256	282	313	341	372	406	441	476	509	539	560	575	588	599
6652	259	285	317	345	377	411	446	482	516	546	568	583	596	606
6653	263	289	321	350	382	416	452	488	522	553	575	590	603	614
6654	266	292	325	354	386	421	457	494	528	559	582	597	611	621
6655	269	296	329	358	391	426	463	499	535	566	589	604	618	629
6656	272	299	333	362	396	431	468	505	541	572	595	611	625	636
6657	275	302	336	366	400	436	473	511	547	579	602	618	632	643
6658	278	306	340	370	405	441	479	517	553	585	609	625	639	650
6659	281	309	344	374	409	445	484	522	559	592	615	632	646	657
6660	284	312	347	378	413	450	489	528	565	598	622	638	653	664
6661	287	316	351	382	418	455	494	533	571	604	628	645	660	671
6662	290	319	354	386	422	459	499	539	577	610	635	652	667	678
6663	293	322	358	390	426	464	504	544	582	617	641	658	673	685
6664	296	325	361	394	430	468	509	549	588	623	647	665	680	692

RESERVOIR OUTFLOW RATING TABLE (continued) IN CUBIC FEET PER SECOND (CFS)

STEM OPENING IN INCHES

ELEV	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6665	6	14	23	35	48	66	83	103	120	143	163	187	213	240	268
6666	6	14	23	35	49	66	84	104	122	144	165	189	215	242	270
6667	6	14	24	35	49	67	85	105	123	145	166	190	217	244	273
6668	6	15	24	36	49	68	86	106	124	147	168	192	219	247	275
6669	6	15	24	36	50	68	87	107	125	148	169	194	221	249	278
6670	6	15	24	36	50	69	87	108	126	149	171	195	223	251	280
6671	6	15	24	37	51	69	88	108	127	151	172	197	225	253	283
6672	6	15	25	37	51	70	89	109	128	152	174	199	227	255	285
6673	6	15	25	37	52	71	90	110	129	153	175	200	229	257	287
6674	6	15	25	38	52	71	90	111	130	154	176	202	231	259	290
6675	6	15	25	38	52	72	91	112	131	156	178	204	233	262	292
6676	6	16	25	38	53	72	92	113	132	157	179	205	234	264	294
6677	6	16	26	39	53	73	92	114	133	158	181	207	236	266	297
6678	6	16	26	39	54	73	93	115	134	159	182	208	238	268	299
6679	6	16	26	39	54	74	94	116	135	161	183	210	240	270	301
6680	6	16	26	40	55	75	95	117	136	162	185	212	242	272	304
6681	6	16	26	40	55	75	95	117	137	163	186	213	243	274	306
6682	6	16	27	40	55	76	96	118	138	164	188	215	245	276	308
6683	7	16	27	40	56	76	97	119	139	165	189	216	247	278	310
6684	7	17	27	41	56	77	97	120	140	167	190	218	249	280	312
6685	7	17	27	41	57	77	98	121	141	168	192	219	250	281	315
6686	7	17	27	41	57	78	99	122	142	169	193	221	252	283	317
6687	7	17	28	42	57	78	99	122	143	170	194	222	254	285	319
6688	7	17	28	42	58	79	100	123	144	171	195	224	255	287	321
6689	7	17	28	42	58	79	101	124	145	172	197	225	257	289	323
6690	7	17	28	42	58	80	101	125	146	173	198	227	259	291	325
6691	7	17	28	43	59	80	102	126	147	175	199	228	260	293	327
6692	7	17	28	43	59	81	103	126	148	176	201	230	262	295	329
6693	7	18	29	43	60	81	103	127	149	177	202	231	264	297	332
6694	7	18	29	44	60	82	104	128	150	178	203	232	265	298	334
6695	7	18	29	44	60	82	105	129	151	179	204	234	267	300	336
6696	7	18	29	44	61	83	105	130	152	180	205	235	269	302	338
6697	7	18	29	44	61	83	106	130	152	181	207	237	270	304	340
6698	7	18	30	45	61	84	107	131	153	182	208	238	272	306	342
6699	7	18	30	45	62	84	107	132	154	183	209	239	273	307	344
6700	7	18	30	45	62	85	108	133	155	184	210	241	275	309	346
6701	7	18	30	45	63	85	108	133	156	185	212	242	276	311	348
6702	7	19	30	46	63	86	109	134	157	186	213	244	278	313	350
6703	7	19	30	46	63	86	110	135	158	187	214	245	280	314	352
6704	8	19	31	46	64	87	110	136	159	188	215	246	281	316	354
6705	8	19	31	46	64	87	111	136	159	190	216	248	283	318	355
6706	8	19	31	47	64	88	111	137	160	191	217	249	284	319	357
6707	8	19	31	47	65	88	112	138	161	192	219	250	286	321	359
6708	8	19	31	47	65	89	113	139	162	193	220	252	287	323	361
6709	8	19	31	47	65	89	113	139	163	194	221	253	289	324	363
6710	8	19	32	48	66	89	114	140	164	195	222	254	290	326	365
6711	8	20	32	48	66	90	114	141	165	196	223	255	292	328	367
6712	8	20	32	48	66	90	115	141	165	197	224	257	293	329	369
6713	8	20	32	48	67	91	116	142	166	198	225	258	295	331	371
6714	8	20	32	49	67	91	116	143	167	199	227	259	296	333	372
6715	8	20	32	49	67	92	117	144	168	200	228	261	297	334	374
6716	8	20	33	49	68	92	117	144	169	201	229	262	299	336	376

RESERVOIR OUTFLOW RATING TABLE (continued) IN CUBIC FEET PER SECOND (CFS)

STEM OPENING IN INCHES

ELEV	16	17	18	19	20	21	22	23	24	25	26	27	28	29
6665	299	328	365	398	435	473	514	555	594	629	654	671.	686	698
6666	302	331	368	401	439	477	519	560	599	635	660	677	693	705
6667	304	334	372	405	443	481	524	565	605	640	666	684	699	711
6668	307	337	375	409	447	486	528	570	610	646	672	690	706	718
6669	310	340	378	412	451	490	533	575	616	652	678	696	712	724
6670	313	343	382	416	455	494	538	580	621	658	684	702	718	731
6671	315	346	385	420	459	499	542	585	626	663	690	708	725	737
6672	318	349	388	423	463	503	547	590	632	669	696	714	731	743
6673	321	352	391	427	467	507	551	595	637	675	701	720	737	749
6674	323	355	395	430	470	511	556	600	642	680	707	726	743	756
6675	326	358	398	434	474	515	560	605	647	686	713	732	749	762
6676	328	361	401	437	478	519	565	610	652	691	719	738	755	768
6677	331	363	404	441	482	523	569	615	657	697	724	743	761	774
6678	334	366	407	444	486	527	574	619	663	702	730	749	767	780
6679	336	369	410	447	489	531	578	624	668	707	735	755	772	786
6680	339	372	413	451	493	535	582	629	672	713	741	760	778	791
6681	341	375	416	454	497	539	587	633	677	718	746	766	784	797
6682	344	377	419	457	500	543	591	638	682	723	752	771	790	803
6683	346	380	422	460	504	547	595	642	687	728	757	777	795	809
6684	348	383	425	464	507	550	599	647	692	733	762	782	801	814
6685	351	385	428	467	511	554	603	651	697	738	768	788	806	820
6686	353	388	431	470	514	558	608	656	702	743	773	793	812	826
6687	356	390	434	473	518	562	612	660	706	748	778	799	818	831
6688	358	393	437	476	521	565	616	665	711	753	783	804	823	837
6689	360	396	440	480	525	569	620	669	716	758	788	809	828	842
6690	363	398	442	483	528	573	624	674	720	763	793	815	834	848
6691	365	401	445	486	532	576	628	678	725	768	799	820	839	853
6692	367	403	448	489	535	580	632	682	729	773	804	825	845	859
6693	370	406	451	492	539	584	636	686	734	778	809	830	850	864
6694	372	408	454	495	542	587	640	691	739	783	814	835	855	869
6695	374	411	456	498	545	591	644	695	743	788	819	840	860	875
6696	377	413	459	501	549	594	648	699	747	792	824	845	866	880
6697	379	416	462	504	552	598	651	703	752	797	828	850	871	885
6698	381	418	465	507	555	601	655	707	756	802	833	855	876	890
6699	383	420	467	510	558	605	659	711	761	806	838	860	881	896
6700	385	423	470	513	562	608	663	716	765	811	843	865	886	901
6701	388	425	473	516	565	612	667	720	769	816	848	870	891	906
6702	390	428	475	519	568	615	670	724	774	820	853	875	896	911
6703	392	430	478	521	571	618	674	728	778	825	857	880	901	916
6704	394	432	480	524	574	622	678	732	782	829	862	885	906	921
6705	396	435	483	527	577	625	681	736	787	834	867	890	911	926
6706	398	437	486	530	581	628	685	740	791	838	871	894	916	931
6707	401	439	488	533	584	632	689	744	795	843	876	899	921	936
6708	403	442	491	536	587	635	692	748	799	847	881	904	926	941
6709	405	444	493	538	590	638	696	751	803	852	885	909	930	946
6710	407	446	496	541	593	642	700	755	807	856	890	913	935	951
6711	409	449	498	544	596	645	703	759	812	861	894	918	940	955
6712	411	451	501	547	599	648	707	763	816	865	899	923	945	960
6713	413	453	503	549	602	651	710	767	820	869	903	927	950	965
6714	415	455	506	552	605	654	714	771	824	874	908	932	954	970
6715	417	457	508	555	608	658	717	774	828	878	912	936	959	975
6716	419	460	511	557	611	661	721	778	832	882	917	941	964	979